DECLARATION

I, Masaaki Hagiwara, of c/o SHIGA INTERNATIONAL PATENT OFFICE, 2-3-1 Yaesu, Chuo-ku, Tokyo 104-8453 JAPAN, understand both English and Japanese, am the translator of the English document attached, and do hereby declare and state that the attached English document contains an accurate translation of the official certified copy of Japanese Patent Application No. 2003-35188 and that all statements made herein are true to the best of my knowledge.

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[Title of the Invention] Optical communication network system

[Claims]

[Claim 1] An optical communication network system comprising:

a wavelength routing device having n (n is an integer equal to 2 or greater) input ports and m (m is an integer equal to 2 or greater) output ports and having a routing function to receive input signal light at said input ports and output it from a specific output port based on the wavelength of said signal light; wherein

I (I is an integer equal to 2 or greater) communication terminals or communication nodes; and

optical fibers connecting said communication terminals or communication nodes and said wavelength routing device to establish a communication path; wherein:

the correspondence between the signal light wavelengths used by said communication terminals or communication nodes for communication and said input/output ports of said wavelength routing device is determined so that two or more of said communication terminals or communication nodes establish a specific logical topology; and

said communication terminals or communication nodes have a means for switching the signal light wavelength for communication.

[Claim 2] The optical communication network system according to Claim 1 wherein:

two or more logical network topologies are constituted by two or more of said communication terminals or communication nodes; and

a means for switching the signal light wavelengths used by said communication terminals or communication nodes for communication is provided in order to connect or transfer a communication terminal or communication node on a specific logical network topology to another logical network topology.

[Claim 3] The optical communication network system according to Claim 2 wherein said wavelength switching means is provided with any of a multi-wavelength light source array, multiple transceiver transmitting/receiving signal lights of different wavelengths, and a wavelength tunable light source at the communication terminal or communication node.

[Claim 4] The optical communication network system according to Claim 2 wherein said wavelength switching means is provided to said communication terminals or communication nodes along with a wavelength tunable filter transmitting light of a specific wavelength on the receiving side.

[Claim 5] The optical communication network system according to Claim 1 wherein it has

two or more logical network topologies that are independent from each other.

[Claim 6] The optical communication network system according to Claim 1 wherein said logical network topologies include at least any one of logical ring network, logical star network, and logical mesh network topologies.

[Claim 7] The optical communication network system according to Claim 1 wherein two or more of said wavelength routing devices communicably connected to each other are provided.

[Claim 8] The optical communication network system according to Claim 1 wherein said communication terminals or communication nodes have two or more different communication paths connected to said wavelength routing device and said logical network topology including two or more of said communication terminals or communication nodes is a logical ring network topology.

[Claim 9] The optical communication network system according to Claim 1 wherein said communication terminals or communication nodes have a primary communication path consisting of two or more different communication paths connected to said wavelength routing devices and a secondary communication path having the same configuration as said primary communication path.

[Claim 10] The optical communication network system according to Claim 1 wherein said logical network topology is a logical ring network topology;

said communication terminals or communication nodes belonging to said logical ring network topology each have two communication paths that allow communication in opposite directions; and

said communication terminals or communication nodes have a means for returning signal light that is received on one of said communication paths and supposed to be output on the other communication path to said one communication path when said other communication path is dis-connected.

[Claim 11] The optical communication network system according to Claim 1 wherein said logical network topology is a logical ring network topology;

said communication terminals or communication nodes belonging to said logical ring network topology each have two communication paths that allow communication in opposite directions; and

said communication terminals or communication nodes have a means for switching the signal light wavelength so that they can skip a disabled communication terminal or communication node and communicate with the subsequent communication terminal or communication node when communication with a communication terminal or communication node on one of the communication paths is disabled.

[Claim 12] The optical communication network system according to Claim 1 wherein said communication terminals or communication nodes are connected to said wavelength routing device via single-core optical fibers.

[Claim 13] The optical communication network system according to Claim 1 wherein said wavelength routing device is a periodic wavelength arrayed wavelength diffraction grating (AWG).

[Claim 14] The optical communication network system according to Claim 1 wherein:

a control node connected to each of said communication terminals or communication nodes for transmitting/receiving control signals is provided; and

control transmission/reception devices for transmitting/receiving said control signals are each provided to said communication terminals or communication nodes.

[Claim 15] The optical communication network system according to Claim 14 wherein said communication terminals or communication nodes each comprise a means for transmitting/receiving said control signals as signal light, a means for multiplexing signal lights for actual signals transferred between said communication terminals or communication nodes and signal light for said control signals, and a means for de-multiplexing said signal light for actual signals and said signal light for control signals from the multiplexed signal light of said signal lights for actual and control signals.

[Claim 16] The optical communication network system according to Claim 14 wherein said control signals are transferred on a different communication path from that for said actual signals between said communication terminals or communication nodes and the control node.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]

The present invention relates to an optical communication network system having high security, stability, distributed loads and functions, and easily changeable logical network topologies, whereby having possible applications in Internet data center (iDCs) and Internet Exchange (IX) networks, as represented by local government networks.

[0002]

[Prior Art]

Historically, the traffic volume on optical communication networks changes every second and has been increasing at an explosive rate as represented by data centers. Furthermore, an increasing number of communication terminals or communication nodes and data types are involved in an optical communication network. Network topologies and connection modes or traffic capacities are required to be dynamically changed.

[0003]

There is a growing demand for techniques to connect networks having different topologies with security or overlap networks having different signal formats and operation policies in a simple and low cost manner and operate them at low cost.

[0004]

[Non-patent Document 1]

K Kato et al., "32 x 32 full-mesh (1024 path) wavelength-routing WDM network based uniform-loss cyclic frequency arrayed-waveguide grating," Electronics Letters, vol. 33,

1865-1866, 1997.

[0005]

[Problems to be Solved by the Invention]

However, in an attempt to connect different independent communication networks having the prior art optical communication network structures, it is difficult to reconstitute network topologies because they often have different network topologies, network policies, and operation systems. Therefore, they should be connected while using their respective network topologies. Consequently, the operation cost will be increased.

[0006]

Furthermore, when information is exchanged in different signal formats such as Ether and ATM formats on optical communication networks, a network has to be established for each signal type.

[0007]

In addition, an optical communication network on which different policies and signal formats are used only has logical structure security such as VLA and VPN. Problems to realize it include high network techniques and increased operation cost.

[0008]

One solution is to install independent optical fibers for each optical communication network. However, this hampers flexible design changes and operation.

[0009]

In view of the above problems, the purpose of the present invention is to realize an optical communication network easily realizing flexible network design, construction, and operation, allowing different networks to be easily connected to each other, and assuring high security and stable operation in case of failures on a simple network structure.

[0010]

[Means for Solving the Problem]

In order to achieve the above purpose, the present invention proposes an optical communication network system comprising a wavelength routing device having n (n is an integer equal to 2 or greater) input ports and m (m is an integer equal to 2 or greater) output ports and having a routing function to receive input signal light at the input ports and output it from a specific output port based on the wavelength of the signal light; I (I is an integer equal to 2 or greater) communication terminals or communication nodes; and optical fibers connecting the communication terminals or communication nodes and the wavelength routing device to establish a communication path, wherein the correspondence between the signal light wavelengths used by the communication terminals or communication nodes for communication and the input/output ports of the wavelength routing device is determined so that two or more of the communication terminals or communication nodes establish a specific logical topology; and the communication terminals or communication nodes have a means for switching the signal light wavelength for communication.

[0011]

According to the present invention, the correspondence between signal light wavelengths used by the communication terminals or communication nodes for communication and the input/output ports of the wavelength routing device is determined so that two or more communication terminals or communication nodes connected to the wavelength routing device physically in a star shape constitute a logical ring network topology.

[0012]

Through signal light wavelength distribution, two or more logical network topologies independent from each other can be constituted by two or more communication terminals or communication nodes and new communication terminals or communication nodes can be added to a specific logical network. Furthermore, communication terminals or communication nodes can easily be transferred between different logical network topologies without relocating or adding communication cables. In addition, through signal light wavelength distribution, logical ring network, logical star, or logical mesh topologies can easily be constituted.

[0013]

The present invention further proposes an optical communication network system having the above structure wherein two or more logical network topologies are constituted by two or more communication terminals or communication nodes; and a means for switching the signal light wavelengths used by the communication terminals or communication nodes for communication is provided in order to connect or transfer a communication terminal or communication node on a specific logical network topology to another logical network topology.

[0014]

According to the present invention, a communication terminal or communication node can easily be transferred between different logical network topologies without relocating or adding communication cables by switching the signal light wavelengths using the wavelength switching means.

[0015]

The present invention further proposes an optical communication network system having the above structure wherein the wavelength switching means is provided with any of a multi-wavelength light source array, multiple transceiver transmitting/receiving signal lights of different wavelengths, and a wavelength tunable light source at the communication terminal or communication node.

[0016]

According to the present invention, the wavelength switching means is provided with any of a multi-wavelength light source array, multiple transceivers transmitting/receiving signal lights of different wavelengths, and a wavelength tunable light source, whereby the signal light wavelengths from the communication terminals or communication nodes can easily be switched.

[0017]

The present invention further proposes an optical communication network system having the above structure wherein the wavelength switching means is provided to the communication terminals or communication nodes along with a wavelength tunable filter transmitting light of a

specific wavelength on the receiving side.

[0018]

According to the present invention, the wavelength switching means is provided with a wavelength tunable filter, whereby the signal light wavelengths received by the communication terminals or communication nodes can easily be switched.

[0019]

The present invention further proposes an optical communication network system having the above structure wherein two or more logical network topologies independent from each other are constituted.

[0020]

According to the present invention, the correspondence between the signal light wavelengths used by the communication terminals or communication nodes for communication and the input/output ports of the wavelength routing device is determined so that different logical network topologies are independent from each other.

[0021]

The present invention further proposes an optical communication network system having the above structure wherein the logical network topologies include at least any one of logical ring network, logical star network, and logical mesh network topologies.

[0022]

The present invention further proposes an optical communication network system having the above structure wherein two or more wavelength routing devices communicably connected to each other are provided.

[0023]

According to the present invention, two or more wavelength routing devices are communicably connected to each other, whereby a logical network topology connecting communication terminals or communication nodes connected to these wavelength routing devices can be constituted.

[0024]

The present invention further proposes an optical communication network system having the above structure wherein the communication terminals or communication nodes have two or more different communication paths connected to the wavelength routing device and the logical network topology including two or more communication terminals or communication nodes is a logical ring network topology.

[0025]

According to the present invention, the communication signal light wavelengths of a communication terminal or communication node are determined so that the communication terminal or communication node is connected to some communication terminals or communication nodes on one path and to other communication terminals or communication nodes on the other path so as to constitute logical ring network topologies.

[0026]

The present invention further proposes an optical communication network system having the above structure wherein the communication terminals or communication nodes have a primary communication path consisting of two or more different communication paths connected to the wavelength routing devices and a secondary communication path having the same configuration as the primary communication path.

[0027]

According to the present invention, a network communication can be maintained by using the secondary communication path when communication through the primary communication path is disabled.

[0028]

The present invention further proposes an optical communication network system having the above structure wherein the logical network topology is a logical ring network topology; the communication terminals or communication nodes belonging to the logical ring network topology each have two communication paths that allow communication in opposite directions; and the communication terminals or communication nodes have a means for returning signal light that is received on one of the communication paths and supposed to be output on the other communication path to the one communication path when the other communication path is dis-connected.

[0029]

According to the present invention, a communication network can be maintained by constituting a logical network topology in which signal light is returned by a communication terminal or communication node connected to a disabled communication terminal or communication node when any failure occurs in the communication path and communication with a specific communication terminal or communication node is disabled.

[0030]

The present invention further proposes an optical communication network system having the above structure wherein the logical network topology is a logical ring network topology; the communication terminals or communication nodes belonging to the logical ring network topology each have two communication paths that allow communication in opposite directions; and the communication terminals or communication nodes have a means for switching the signal light wavelength so that they can skip a disabled communication terminal or communication node and communicate with the subsequent communication terminal or communication node when communication with a communication terminal or communication node on one of the communication paths is disabled.

[0031]

According to the present invention, a communication network can be maintained by constituting a logical ring network topology in which a disabled communication terminal or communication node is skipped when any failure occurs in the communication path and communication with a specific communication terminal or communication node is disabled.

[0032]

The present invention further proposes an optical communication network system having the above structure wherein the communication terminals or communication nodes are connected to the wavelength routing device via single-core optical fibers.

[0033]

According to the present invention, the communication terminals or communication nodes are connected to the wavelength routing device using single-core optical fibers, which reduces cost compared to the connection by twin-core optical fibers.

[0034]

The present invention further proposes an optical communication network system having the above structure wherein the wavelength routing device is a periodic wavelength arrayed wavelength diffraction grating (AWG).

[0035]

According to the present invention, the wavelength routing device is constituted by a periodic wavelength arrayed waveguide diffraction grating (AWG), which allows down-sizing of the device.

[0036]

The present invention further proposes an optical communication network system having the above structure wherein a control node connected to each of the communication terminals or communication nodes for transmitting/receiving control signals is provided; and control transmission/reception devices for transmitting/receiving the control signals are each provided to the communication terminals or communication nodes.

[0037]

According to the present invention, control signals are transmitted/received between the control node and the communication terminals or communication nodes for controlling the states of the communication terminals or communication nodes.

[0038]

The present invention further proposes an optical communication network system having the above structure wherein the communication terminals or communication nodes each comprise a means for transmitting/receiving the control signals as signal light, a means for multiplexing signal lights for actual signals transferred between the communication terminals or communication nodes and signal light for the control signals, and a means for de-multiplexing the signal light for actual signals and the signal light for control signals from the multiplexed signal light of the signals light for actual and control signals.

[0039]

According to the present invention, the communication terminals or communication nodes multiplex and transfer control and actual signal lights and receive and de-multiplex the multiplexed control and actual signal lights, whereby the states of the communication terminals or communication nodes can be controlled without increasing optical fibers in number connected to the communication terminals or communication nodes.

[0040]

The present invention further proposes an optical communication network system having the above structure wherein the control signals are transferred on a different communication path from that for actual signals between the communication terminals or communication nodes and the control node.

[0041]

[Embodiments of the Invention]

Embodiments of the present invention are described in detail hereafter with reference to the drawings.

[0042]

In the embodiments described below, the numbers of input and output ports of the wavelength routing device and the number of communication terminals or communication nodes, m, n, and I, respectively, are 4, 5, 13, or 14. However, these numbers are not restrictive and can be 2 or greater.

[0043]

Furthermore, the present invention is described as a network including one logical network. However, two or more similar networks can be similarly included.

[0044]

Similarly, when the present invention is multiplexed for redundancy, not only 2 but also two or more similar networks established in parallel are not excluded from the scope of the claims of the present invention.

[0045]

An amplifier may be necessary because of optical transfer loss in establishing a network. The amplifier can be placed somewhere between transmission/reception devices.

[0046]

[Embodiment 1]

Fig.1 shows a physical topology of Embodiment 1 according to the optical network system of the present invention. In Fig.1, a wavelength routing device 101 is, for example, an arrayed waveguide diffraction grating (AWG), which is a typical wavelength routing device.

[0047]

As shown in Figs. 2 and 3, the wavelength routing device 101 has input ports 201-205 and output ports 301-305, which are connected to distributed communication terminals such as personal computers or communication nodes serving as connection points in the communication network such as routers (which are collectively termed communication terminal nodes hereafter) 401-405 via optical fibers 501-505, respectively. The communication terminal nodes 401-405 each have a means (not shown) for switching the signal light wavelength used for communication.

[0048]

Fig.2 shows an exemplary connection between the wavelength touring device 101 and the communication terminal nodes 401-405 via twin-core optical fibers. Fig.3 shows an exemplary connection between the wavelength touring device 101 and the communication terminal nodes

401-405 via single-core optical fibers.

[0049]

An arrayed waveguide diffraction grating (AWG) having the input ports 201-205 and output ports 301-305 is used as the wavelength routing device 101 of a typical type. The distributed communication terminal nodes 401-405 are connected to the input/output ports 201-205, 301-305 via the optical fibers 501-505, respectively.

[0050]

The wavelength routing device 101 receives signals 601-605 from the communication terminal nodes 401-405 at the input ports 201-205 and outputs them from the corresponding one of the output ports 301-305 depending on the wavelength.

[0051]

The communication terminal nodes 401-405 switch to/select signal light of the wavelength set for the target (destination) communication node 401-405 before sending it out. In this way, a network topology that is logically a star (mesh) network topology as shown in Fig.4 or a ring network topology as shown in Fig.5 can easily be realized although it is physically a simple star network structure as the physical topology shown in Fig.1.

[0052]

Figs. 4 and 5 show signal transmission path images (wavelength paths) and the logical topology structures of the transmission paths.

[0053]

For constituting the star (mesh) network topology shown in Fig.4, the connections between the input/output ports 201-205 and 301-305 based on signal light wavelengths and the signal light wavelengths used by the communication terminal nodes 401-405 are determined as shown in the wavelength distribution of Fig.6. Here, the wavelengths hatched in Fig.4 are used.

[0054]

For constituting the ring network topology shown in Fig.5, the connections between the input/output ports 201-205 and 301-305 based on signal light wavelengths and the signal light wavelengths used by the communication terminal nodes 401-405 are determined as shown in the wavelength distribution shown in Fig.7. Here, the wavelengths hatched in Fig.5 are used.

[0055]

Using two or more wavelength touting devices communicably connected, a specific logical network topology can be constituted between communication terminal nodes connected to these wavelength touting devices.

[0056]

[Embodiment 2]

Figs. 8 to 10 show Embodiment 2 of the optical network system of the present invention.

In this embodiment, the characteristics of the present invention are described in detail using an extension scheme of an optical communication network system as an example.

[0057]

In Embodiment 2, a small-scale physical network structure of a simple star topology is

realized as shown in Fig.8. Here, five bases 402A-406A having communication terminal nodes 402-406 are connected to a central base 401A having the wavelength routing device 101 described in Embodiment 1.

[0058]

Fig.9 shows a physical network structure extended from the network structure in Fig.8 and having an increased number of communication terminal nodes. Fig.10 shows a logical network structure on the structure in Fig.9.

[0059]

The optical communication network shown in Fig.9 is an example where extended bases 407A-418A having communication terminal nodes 407-418 connected to the wavelength routing device 101 at the central base 401A are provided. In the optical communication network shown in Fig.9, as shown in Fig.10, a logical star (mesh) network topology is constituted by the bases 401A, 402A and the extended bases 413A-416A, a logical ring network topology is constituted by the bases 401A, 405A and the extended bases 409A-412A, and a logical star (mesh) network topology is constituted by the bases 401A, 403A, 404A and the extended bases 417A, 418A. Furthermore, a logical star (mesh) network topology is constituted by the bases 401A, 405A and the extended bases 412A, 418A.

[0060]

In an actual network design, a large-scale network as shown in Fig.9 is not contemplated from the beginning of network construction. Usually, a network is gradually up-scaled from the network structure as shown in Fig.8 according to extended network operation conditions and size. In Embodiment 2, based on the network structure in Fig.8, the communication terminal nodes 401-418 are connected to the wavelength routing device 101 by optical fibers up to the number of input/output ports of the wavelength routing device (AWG) 101 at the center for extension, whereby the extended bases 407A-418A are added. In this way, a larger-scale network can easily be realized without interfering with or discontinuing the communication between the existing communication terminal nodes 401-406.

[0061]

In the network structure of this embodiment, as shown in Embodiment 1 above (Fig.1), not only a star (mesh) topology but also a ring logical topology can easily be constituted. As shown in Fig.10, an optical communication network system in which different, mesh, star, and ring, logical network topologies are simultaneously present can be constituted on one and the same network having a physically star topology.

[0062]

In this structure, the destination can be selected simply by changing the signal light wavelength transmitted from the communication terminal nodes 401-418. No prolonged period of time or high construction cost is necessary to reconnect optical fibers in the initial physical network structure for changing a logical network topology. A logical network topology can be changed in a very short period of time and at low cost. A logical network topology can also be changed by changing wavelength distribution at the input/output ports of the wavelength

routing device 101.

[0063]

[Embodiment 3]

Figs. 11 and 14 show Embodiment 3 of the optical communication network of the present invention. Fig.11 shows a physical network structure and Fig.12 shows a logical network topology thereof. Fig.13 is an illustration for explaining the logical structure of the network structure of Embodiment 3. Fig.14 is an illustration showing the wavelength distribution at the input/output ports of the wavelength routing device 101 of Embodiment 3. Here, an application in an Internet data center (iDC) network is shown.

[0064]

Data centers 701A-705A having communication terminal nodes 701-705 are connected to the central base 101A having the wavelength routing device 101 via optical fibers and bases 706A-713A having communication nodes 706-713 are connected to the central base 101A via optical fibers.

[0065]

By setting the signal light wavelengths of the wavelength routing device 101 and communication nodes 701-713, a logical star (mesh) network topology is constituted by the data centers 701A-705A to establish a distributed data center WDM (Wavelength Division Multiplexing) core network 721. An MPLS (Multi-protocol Label Switching) core network (logical full-mesh network topology) 722 is established by the communication nodes 701-705 of the data centers 701A-705A and the communication nodes 706 and 710. Furthermore, a RPR (Resilient Packer Ring) network (logical ring network topology) 723 is established by the communication nodes 706-709. An Ether network (logical star network topology) 724 is established by the communication nodes 710-713. An inter-building mutual connection network 725 having point-point connection of a simple star structure is established by the communication nodes 707 and 713.

[0066]

In this embodiment, as described in Embodiments 1 and 2, a logical star (mesh) network topology and a logical ring network topology can be simultaneously present in spite of a physically simple star structure as shown in Fig.11. In addition, network control techniques such as the MPLS (Multi-protocol Label Switching), or a known path control method, and the RPR (Resilient Packer Ring), or a known high speed failure bypass method, can be overlapped. Therefore, a significantly stable and high security network, such as a network on which the communication nodes 701-705 of the data centers 701A-705A are distributed and an Internet Exchange (IX) network, can be constituted in a short period of time and at low cost.

[0067]

In Fig.14, the node numbers 1-16 represent the input/output ports of the wavelength routing device 101. In this embodiment, the input/output ports having the node numbers 1-13 are connected to the communication terminal nodes 701-713, respectively, and the signal light wavelength distribution at the communication terminal nodes 701-713 are set. In this case, as

described above, the number of the communication terminal nodes is 13.

[0068]

With this wavelength distribution, as shown in Figs. 11 and 12, the communication nodes 706-709 connected to the logical ring network topology are connected to the communication nodes 701-705 of the mesh-connected data centers 701-705. Here, the communication nodes 701-705, 706, and 719 are LSRs (Label Switch Routers) of the MPLS. The communication node 706 is the LSR (Label Switch Router) boundary of the MPLS. The communication nodes 710-713 easily realize a logical network structure of a simple star connection. The communication nodes 710-713 are connected to the communication nodes 701-705 of the mesh-connected data centers 701-705. Here, the communication node 710 is the LSR (Label Switch Router) boundary of the MPLS.

[0069]

In this embodiment, as shown in Fig.14, the MPLS core network 721 of a logical star (mesh) topology uses wavelengths λ1-λ9; the RPR network 723 of a logical ring network topology uses wavelengths λ12-λ16; the Ether network 724 of a logical star topology uses wavelengths λ4-λ9; and the inter-building mutual connection network 725 uses wavelengths λ3.

[0070]

Here, the wavelength distribution is based on an AWG having a size of 16 x 16 as the wavelength routing device 101 at the center. The size is not restricted to 16 x 16 and any size larger than the number of included communication nodes can be used.

[0071]

[Embodiment 4]

Embodiment 4 of the optical communication network system of the present invention is described hereafter with reference to Figs. 15 and 16. In Embodiment 4, another communication node 714 is added in the structure in Embodiment 3. Fig.15 shows the logical network structure of Embodiment 4. Fig.16 shows the wavelength distribution at the input/output ports of the wavelength routing device 101 in Embodiment 3 described above. In Fig.16, the node numbers 1-16 represent the input/output ports of the wavelength routing device 101. In this embodiment, the input/output ports having the node numbers 1-14 are connected to the communication terminal nodes 701-714, respectively, and the signal light wavelength distribution at the communication terminal nodes 701-714 are set. In this case, as described above, the number of the communication terminal nodes is 14.

[0072]

In this embodiment, a new communication terminal node 714 is interposed between the communication nodes 708 and 709 in the logical ring network topology of the RPR network 723 of Embodiment 3. Here, as shown in Fg.16, the communication wavelengths among the communication nodes 708, 709, and 714 are reset so that a wavelength λ5 is used for communication between the communication nodes 708 and 714 and a wavelength λ6 is used for communication between the communication nodes 709 and 714 instead of signal light of a wavelength λ16 being used for communication between the communication nodes 708 and 709

before this modification. In this way, the new communication node 714 is added on the network simply by resetting the communication wavelengths among the communication nodes 708, 709, and 714. Here, the wavelength routing device 101 located at the logical center is a 16 x 16 AWG. As mentioned above, the size of 16 x 16 is not restrictive and any size larger than the number of included communication nodes can be used.

[0073]

[Embodiment 5]

Embodiment 5 of the optical communication network system of the present invention is described hereafter with reference to Figs. 17 and 18. In Embodiment 5, the communication node 707 on the logical ring network topology of the RPR network 723 in Embodiment 4 is transferred to the Ether network 724 of a logical ring topology. Fig.17 shows the logical network structure of Embodiment 5. Fig.18 shows the wavelength distribution at the input/output ports of the wavelength routing device 101. In Fig.18, the node numbers 1-16 represent the input/output ports of the wavelength routing device 101 the same way as above. In this embodiment, the input/output ports having the node numbers 1-14 are connected to the communication terminal nodes 701-714, respectively, and the signal light wavelength distribution at the communication terminal nodes 701-714 are set. Also in this case, the number of the communication terminal nodes is 14.

[0074]

This embodiment explains the logical network structure and wavelength setting for the communication terminal modes when the communication node 707 included in the logical ring network topology where the communication node 714 is inserted is transferred to the star network to which the communication terminal 710 belongs and the logical topology is changed. Here, the communication wavelength of the communication node 707 is set for a wavelength $\lambda16$ and the wavelength $\lambda16$ is used for communication between the communication nodes 707 and 710, instead of the communication terminal node 707 using wavelengths $\lambda12$ and $\lambda14$ for communication with the communication terminal nodes 706 and 708, respectively, before the transfer. In addition, the communication wavelengths among the communication terminal nodes 707, 708, and 709 are set so that a wavelength $\lambda13$ is used for communication between the communication terminal nodes 707 and 708 instead of a wavelength $\lambda12$ being used for communication between the communication terminal nodes 706 and 707 and a wavelength $\lambda13$ being used for communication between the communication terminal nodes 707 and 708 before the transfer.

[0075]

In the above embodiment, a logical network topology can be dynamically changed simply by changing the signal light wavelength distribution for communication. The wavelength routing device 101 located at the center in Fig.18 is a 16 x 16 AWG; however, the size of 16 x 16 is not restrictive and any size larger than the number of included communication nodes can be used.

[0076]

[Embodiment 6]

Embodiment 6 of the optical communication network system of the present invention is described hereafter with reference to Figs. 19 and 20. This embodiment explains a network structure having a wavelength distribution for a logical ring network topology and including four communication terminal nodes 701-704.

[0077]

Fig.19 shows the physical structure of an optical communication network system according to Embodiment 6. Fig.20 shows the logical structure of an optical communication network system and the wavelength distribution of the wavelength routing device 101 according to Embodiment 6. In this embodiment, the wavelength routing device 101 is a periodic 4 x 4 AWG. In the wavelength distribution shown in Fig.20, the node numbers 1-4 represent the input/output port numbers of the wavelength routing device 101. In this embodiment, the input/output ports having the node numbers 1-4 are connected to the communication terminal nodes 701-704, respectively, and the wavelength distribution for the communication terminal nodes 701-7-4 is set. Here, the number of the communication terminal node is 4.

[0078]

In Fig.19, the communication terminal nodes 701-704 each have a WDM interface (termed WDM-IF hereafter) 700a and two media access control parts (termed MAC hereafter) 700b and 700c. The signal light wavelengths for the MACs 700b and 700c are set as follows: one MAC 700b uses signal light of a wavelength λ2 for communication through the WDM-IF 700a and the other MAC 700c uses signal light of a wavelength λ4 for communication through the WDM-IF 700a. Furthermore, the MACs 700b and 700c each have a function to return received signals.

[0079]

With the wavelength distribution of the wavelength routing device 101 as shown Fig.20, signal light of a wavelength λ2 is used for bi-directional communication between the communication terminal nodes 701 and 702, signal light of a wavelength λ4 is used for bi-directional communication between the communication terminal nodes 702 and 703, signal light of a wavelength λ2 is used for bi-directional communication between the communication terminal nodes 703 and 704, and signal light of a wavelength λ4 is used for bi-directional communication between the communication terminal nodes 704 and 701. In this way, the MACs 700b and 700c perform outer circle communication Outer-TX, Outer-Rx and inner circle communication Inner-TX, Inner-RX, constituting a logical ring network topology.

[0080]

With the wavelength distribution shown in the figure, signals go round through all communication nodes 701-704. This embodiment is characterized by bi-directional transfer of signal light. Here, the same wavelength is used for both directions. However, different wavelengths can be used with substantially no changes. Here, the wavelength routing device 101 located at the center is a 4 x 4 AWG. The size of 4 x 4 is not restrictive and any size larger than the number of included communication terminal nodes can be used.

[0081]

With this structure, as shown in Fig.21, the case that the optical fiber connecting the

communication terminal node 701 and the wavelength routing device 101 is dis-connected is described hereafter.

[0082]

In this case, as shown in the logical structure of Fig.22, after the optical fiber connecting the communication terminal node 701 and the wavelength routing device 101 is dis-connected, communication through the direct connections between the communication terminals 701 and 702 and between the communication terminal nodes 701 and 704 can be returned at the communication terminal nodes 702 and 704, respectively, to bypass the failure of the dis-connected optical fiber. When the optical fiber connecting the communication terminal node 701 and the wavelength routing device 101 is dis-connected, the MAC 700c of the communication terminal node 702 returns signals from the communication terminal node 703 to the communication terminal node 703 and the MAC 700b of the communication terminal node 704 returns signals from the communication terminal node 703 to the communication terminal node 703, whereby communication between the communication terminals 702-704 can be maintained.

[0083]

The above process similarly applied to the case that the communication terminal node 701 itself has a failure as shown in Fig.23. It can easily be done to detect such a failure and automatically return signals. Such automated signal returning provides high-speed and stable failure recovery.

[0084]

[Embodiment 7]

Embodiment 7 according to the optical communication network system of the present invention is described hereafter with reference to Figs. 24 and 25. In this embodiment, single-core optical fibers are used and optical non-reciprocal circuits 1001-1008 such as optical circulators are provided at the transmission/reception ports 201-204, 301-304 of the communication terminal nodes and wavelength routing device. Fig.24 is an illustration showing the physical structure of an optical network system according to Embodiment 7. Fig.25 is an illustration for explaining the wavelength distribution in Embodiment 7.

[0085]

In Fig.24, the wavelength routing device 101 is an N x N AWG (N is an integer) having four input ports 201-204 and four output ports 301-304, which are connected to four communication terminal nodes 701-704 via optical non-reciprocal circuits 1001-1008 and single-core optical fibers 501-504.

[0086]

The communication terminal node 701 comprises an optical DEMUX (De-multiplexer) device 1401 having a transmitter 1101, a receiver 1201, and a non-reciprocal circuit 1001. The non-reciprocal circuit 1001 is connected to the output terminal of the transmitter 1101 and to the input terminal of the receiver 1201. It is further connected to the input port 201 and output port 301 of the wavelength routing device 101 via an optical fiber 501 and a non-reciprocal

circuit 1005.

[0087]

The communication terminal node 702 comprises an optical DEMUX (De-multiplexer) device 1402 having a transmitter 1102, a receiver 1202, and a non-reciprocal circuit 1002. The non-reciprocal circuit 1002 is connected to the output terminal of the transmitter 1102 and to the input terminal of the receiver 1202. It is further connected to the input port 202 and output port 302 of the wavelength routing device 101 via an optical fiber 502 and a non-reciprocal circuit 1006.

[0088]

The communication terminal node 703 comprises an optical DEMUX (De-multiplexer) device 1403 having a transmitter 1103, a receiver 1203, and a non-reciprocal circuit 1003. The non-reciprocal circuit 1003 is connected to the output terminal of the transmitter 1103 and to the input terminal of the receiver 1203. It is further connected to the input port 203 and output port 303 of the wavelength routing device 101 via an optical fiber 503 and a non-reciprocal circuit 1007.

[0089]

The communication terminal node 704 comprises an optical DEMUX (De-multiplexer) device 1404 having a transmitter 1104, a receiver 1204, and a non-reciprocal circuit 1004. The non-reciprocal circuit 1004 is connected to the output terminal of the transmitter 1104 and to the input terminal of the receiver 1204. It is further connected to the input port 204 and output port 304 of the wavelength routing device 101 via an optical fiber 504 and a non-reciprocal circuit 1008.

[0090]

The wavelength routing device 101 and non-reciprocal circuits 1001-1008 are set for signal light routing fulfilling the wavelength distribution shown in Fig.25. Signal light of wavelengths $\lambda1$, $\lambda2$, $\lambda3$, and $\lambda4$ transmitted from the communication node 701 is sent to the communication nodes 701, 702, 703, and 704, respectively. Signal light of wavelengths $\lambda4$, $\lambda1$, $\lambda2$, and $\lambda3$ transmitted from the communication node 702 is sent to the communication nodes 701, 702, 703, and 704, respectively. Signal light of wavelengths $\lambda3$, $\lambda4$, $\lambda1$, and $\lambda2$ transmitted from the communication node 703 is sent to the communication nodes 701, 702, 703, and 704, respectively. Signal light of wavelengths$\lambda2$, $\lambda3$, $\lambda4$, and $\lambda1$ transmitted from the communication node 704 is sent to the communication nodes 701, 702, 703, and 704, respectively. In this embodiment, a logical ring network topology is constituted by setting the transmission/reception wavelength of the transmission/reception part of the communication terminal nodes 701-704 for $\lambda2$.

[0091]

[Embodiment 8]

Embodiment 8 of the optical communication network system of the present invention is described hereafter with reference to Fig.26. This embodiment provides a system based on Embodiment 7 shown in Figs. 24 and 25 and in which failure bypass is taken into account for failures such as a dis-connected optical fiber.

[0092]

In Embodiment 6 shown in Figs 19 and 20 and Embodiment 7 shown in Figs 24 and 25, the communication terminal nodes and wavelength routing device are connected using single-core optical fibers. When these optical fibers are dis-connected, a specific communication node 701 is isolated.

[0093]

On the other hand, transmission/reception optical fibers are duplicated in this embodiment. Therefore, a specific communication terminal node is not isolated in case of failures such as a dis-connected optical fiber.

[0094]

In Embodiment 8 shown in Fig.26, two wavelength routing devices 101 and 102 each consist of an N x N AWG (N is an integer) having four input ports 201-204 or 205-208 and four output ports 301-3-4 or 305-308, which are connected to four communication terminal nodes 701-704 via single-core optical fibers 501-516.

[0095]

The communication terminal node 701 comprises a transceiver 1501 having a transmitter 1101 and a receiver 1201 and a transceiver 1502 having a transmitter 1102 and a receiver 1202. The output terminal of the transmitter 1101 of the transceiver 1501 is connected to the input port 201 of the wavelength routing device 101 via an optical fiber 501. The input terminal of the receiver 1201 is connected to the output port 301 of the wavelength routing device 101 via an optical fiber 502. The output terminal of the transmitter 1102 of the transceiver 1502 is connected to the input port 205 of the wavelength routing device 102 via an optical fiber 503. The input terminal of the receiver 1202 is connected to the output port 305 of the wavelength routing device 102 via an optical fiber 504.

[0096]

The communication terminal node 702 comprises a transceiver 1503 having a transmitter 1103 and a receiver 1203 and a transceiver 1504 having a transmitter 1104 and a receiver 1204. The output terminal of the transmitter 1103 of the transceiver 1503 is connected to the input port 202 of the wavelength routing device 101 via an optical fiber 505. The input terminal of the receiver 1203 is connected to the output port 302 of the wavelength routing device 101 via an optical fiber 506. The output terminal of the transmitter 1104 of the transceiver 1504 is connected to the input port 206 of the wavelength routing device 102 via an optical fiber 507. The input terminal of the receiver 1204 is connected to the output port 306 of the wavelength routing device 102 via an optical fiber 508.

[0097]

The communication terminal node 703 comprises a transceiver 1505 having a transmitter 1105 and a receiver 1205 and a transceiver 1506 having a transmitter 1106 and a receiver 1206. The output terminal of the transmitter 1105 of the transceiver 1505 is connected to the input port 203 of the wavelength routing device 101 via an optical fiber 509. The input terminal of the receiver 1205 is connected to the output port 303 of the wavelength routing device 101 via an

optical fiber 510. The output terminal of the transmitter 1106 of the transceiver 1506 is connected to the input port 207 of the wavelength routing device 102 via an optical fiber 511. The input terminal of the receiver 1206 is connected to the output port 307 of the wavelength routing device 102 via an optical fiber 512.

[0098]

The communication terminal node 704 comprises a transceiver 1507 having a transmitter 1107 and a receiver 1207 and a transceiver 1508 having a transmitter 1108 and a receiver 1208. The output terminal of the transmitter 1107 of the transceiver 1507 is connected to the input port 204 of the wavelength routing device 101 via an optical fiber 513. The input terminal of the receiver 1207 is connected to the output port 304 of the wavelength routing device 101 via an optical fiber 514. The output terminal of the transmitter 1108 of the transceiver 1508 is connected to the input port 208 of the wavelength routing device 102 via an optical fiber 515. The input terminal of the receiver 1208 is connected to the output port 308 of the wavelength routing device 102 via an optical fiber 516.

[0099]

With the redundant duplicated structure as described above, the duplicated transmission/reception optical fibers serve to prevent a specific communication terminal node from being isolated in case of failures such as a dis-connected optical fiber.

[0100]

Here, the transceivers 1501-1508 and wavelength routing devices 101, 102 can be connected by twin-core optical fibers.

[0101]

[Embodiment 9]

Embodiment 9 of the optical communication network system of the present invention is described hereafter with reference to Fig. 27. This embodiment provides a system based on Embodiment 7 shown in Fig. 24 and 25 and in which failure bypass is taken into account for failures such as a dis-connected optical fiber as in Embodiment 8.

[0102]

In Embodiment 9, the structure of Embodiment 7 is duplicated to prevent a specific communication terminal node from being isolated in case of failures such as a dis-connected optical fiber between a communication terminal node and the wavelength routing device. In Embodiment 9, single-core optical fibers are used and non-reciprocal circuits such as optical circulators are provided at the transmission/reception ports of the communication terminal nodes and wavelength routing device.

[0103]

In Embodiment 9 shown in Fig.27, two wavelength routing devices 101 and 102 each consist of an N x N AWG (N is an integer) having four input ports 201-204 or 205-208 and four output ports 301-304 or 305-308, which are connected to four communication terminal nodes 701-704 via non-reciprocal circuits 1001-1016 and single-core optical fibers 501-508.

[0104]

The communication terminal node 701 comprises an optical DEMUX device 1401 having a transmitter 1101, a receiver 1201, and a non-reciprocal circuit 1001 and an optical DEMUX device 1402 having a transmitter 1102, a receiver 1202, and a non-reciprocal circuit 1002.

[0105]

The non-reciprocal circuit 1001 is connected to the output terminal 1101 and the input terminal of the receiver 1201. It also connected to the input port 201 and output port 301 of the wavelength routing device 101 via an optical fiber 501 and the non-reciprocal circuit 1005.

[0106]

The non-reciprocal circuit 1002 is connected to the output terminal 1102 and the input terminal of the receiver 1202. It also connected to the input port 205 and output port 305 of the wavelength routing device 102 via an optical fiber 502 and the non-reciprocal circuit 1013.

[0107]

The communication terminal node 702 comprises an optical DEMUX device 1403 having a transmitter 1103, a receiver 1203, and a non-reciprocal circuit 1003 and an optical DEMUX device 1404 having a transmitter 1104, a receiver 1204, and a non-reciprocal circuit 1004.

[0108]

The non-reciprocal circuit 1003 is connected to the output terminal 1103 and the input terminal of the receiver 1203. It also connected to the input port 202 and output port 302 of the wavelength routing device 101 via an optical fiber 503 and the non-reciprocal circuit 1006.

[0109]

The non-reciprocal circuit 1004 is connected to the output terminal 1104 and the input terminal of the receiver 1204. It also connected to the input port 206 and output port 306 of the wavelength routing device 102 via an optical fiber 504 and the non-reciprocal circuit 1014.

[0110]

The communication terminal node 703 comprises an optical DEMUX device 1405 having a transmitter 1105, a receiver 1205, and a non-reciprocal circuit 1009 and an optical DEMUX device 1406 having a transmitter 1106, a receiver 1206, and a non-reciprocal circuit 1010.

[0111]

The non-reciprocal circuit 1009 is connected to the output terminal 1105 and the input terminal of the receiver 1205. It also connected to the input port 203 and output port 303 of the wavelength routing device 101 via an optical fiber 505 and the non-reciprocal circuit 1007.

[0112]

The non-reciprocal circuit 1010 is connected to the output terminal 1106 and the input terminal of the receiver 1206. It also connected to the input port 207 and output port 307 of the wavelength routing device 102 via an optical fiber 506 and the non-reciprocal circuit 1015.

[0113]

The communication terminal node 704 comprises an optical DEMUX device 1407 having a transmitter 1107, a receiver 1207, and a non-reciprocal circuit 1011 and an optical DEMUX device 1408 having a transmitter 1108, a receiver 1208, and a non-reciprocal circuit 1012.

[0114]

The non-reciprocal circuit 1011 is connected to the output terminal 1107 and the input terminal of the receiver 1207. It also connected to the input port 204 and output port 304 of the wavelength routing device 101 via an optical fiber 507 and the non-reciprocal circuit 1008.

[0115]

The non-reciprocal circuit 1012 is connected to the output terminal 1108 and the input terminal of the receiver 1208. It also connected to the input port 208 and output port 308 of the wavelength routing device 102 via an optical fiber 508 and the non-reciprocal circuit 1016.

[0116]

With the redundant duplicated structure as described above, the duplicated transmission/reception optical fibers serve to prevent a specific communication terminal node from being isolated in case of failures such as a dis-connected optical fiber.

[0117]

Furthermore, with the redundant duplicated structure as described above, simultaneous bi-directional signal light transfer prevents a specific communication terminal node from being isolated even if disconnection occurs in one direction no matter which optical fibers are used, single-core or twin-core, whereby a stable network can be constituted.

[0118]

[Embodiment 10]

Embodiment 10 of the optical communication network system of the present invention is described hereafter with reference to Fig.28. The components in Fig.28 that are the same as those in Embodiment 9 shown in Fig.27 are given the same reference numbers and their explanation is omitted. The difference between Embodiments 9 and 10 is that transmitters 910-908 having wavelength tunable light sources are provided in place of the transmitters 1101-1108 in Embodiment 9.

[0119]

When a logical ring network is constituted using the transmitters 901-908 having wavelength tunable light sources, the signal light wavelength can be changed to skip (jump across) a disabled communication terminal node because of a failure, whereby the failure is bypassed. Here, a multi-wavelength light source array can be used to obtain the same effect in place of the wavelength tunable light sources.

[0120]

[Embodiment 11]

In Embodiment 11, an embodiment in which transmitters having wavelength tunable light sources as in Embodiment 10 are used in the optical communication network system of Embodiment 6 is described with reference to Figs. 29 and 30. Fig.29 shows the physical structure of the optical network system of Embodiment 11. Fig.30 shows the logical structure of the optical network system of Embodiment 11.

[0121]

The components in Figs. 29 and 30 that are the same as those of Embodiment 6 shown in Figs. 19 and 20 are given the same reference number and their explanation is omitted.

[0122]

In this embodiment, in the same manner as in Embodiment 6, the wavelength distribution is set for a logical ring network topology and the network includes four communication terminal nodes 701-704. Signals go around through all communication terminal nodes 701-704. This embodiment is characterized by uni-directional or bi-directional signal light transfer. For disconnection of a specific optical fiber or a failure in a specific communication terminal node, the transmission wavelength is selected by the wavelength tunable light source provided at the communication terminal nodes 701-704 so that signals are transferred from the communication terminal node right before the failure point to the subsequent communication terminal node while skipping (jumping across) the failed communication terminal node.

[0123]

For example, as shown in Fig.29, when the communication between the communication terminal node 701 and the wavelength routing device 101 is disabled, in other words, the communication between the communication terminal node 701 and the communication terminal nodes 702, 704 is disabled in a logical ring network topology, as shown in Fig.30, the signal light wavelength used by the communication terminal nodes 702, 704 for the communication with communication terminal node 701 is changed to λ1, whereby a logical ring network topology in which the communication between the communication terminal nodes 702 and 704 is available by skipping (jumping across) the communication terminal node 701 is obtained. In this way, a logical ring network topology among communicable communication terminal nodes can be constituted for maintaining the communication in case of failures.

[0124]

Detecting such a failure and automatically switching the signal light wavelength could be easily accomplished. This automated signal light wavelength switching provides high-speed and stable failure by-pass.

[0125]

[Embodiment 12]

Embodiment 12 of the optical communication network system of the present invention is described hereafter with reference to Fig.31. Fig.31 shows the physical structure of the optical communication network system of Embodiment 12.

[0126]

In Embodiment 12, the transmitter 901-904 having wavelength tunable light sources are provided in place of the transmitter 1101-1104 in Embodiment 7 and wavelength tunable filters 1501-1504 are provided between the receivers 1201-1204 and the non-reciprocal circuits (optical circuits) 1101-1004. Here, four communication terminals 701-704 are connected by single-core optical fibers 801-804.

[0127]

Each communication terminal node 701-704 is provided with a transmitter 901-904 having a wavelength tunable light source for transmitting signals to a desired communication terminal node and a wavelength tunable filter 1501-1504 for selecting a signal light wavelength among

various signal light wavelengths sent from the other communication terminal nodes.

[0128]

In this embodiment, each communication terminal is provided with a pair of a receiver 1201-1204 and a wavelength tunable filter 1504-1504. Needless to say, multiple receivers and wavelength tunable filters can be provided in order to concurrently receive signal light of multiple wavelengths.

[0129]

When the logical network topology is changed or communication terminal nodes are added, the wavelengths of transmission light sources have to be changed at the communication terminal nodes involved in communication with those communication nodes. On the other hand, the receiver should selectively receive many wavelengths. To this end, wavelength tunable filers corresponding to the received wavelengths can be simply provided and there is no need of providing receivers more than necessary, which is economically advantageous.

[0130]

In this embodiment, a single path using signal-core optical fibers is explained. However, the above process is similarly applied to a redundant structure or twin-core optical fibers. Furthermore, the number of communication nodes is not restricted to 4.

[0131]

[Embodiment 13]

Embodiment 13 of the optical communication network system of the present invention is described hereafter with reference to Fig.32.

[0132]

Fig.32 shows the network structure of Embodiment 13 in which four communication terminal nodes 701-704 are connected by twin-core optical fibers 501-508. Needless to say, the number of communication terminal nodes is not restricted to 4.

[0133]

Fig.32 shows a wavelength routing device 101 such as AWG as described above, communication terminal nodes 701-704, a control node 1601, and WDM couplers 1801-1816.

[0134]

The communication terminals 701-704 each comprise a control transmission/reception part 1701-1704, a transmission/reception part 2501-2504, WDM couplers 1801-1808, and de-multiplexer 2101-2104.

[0135]

The control transmission/reception part 1701-1704 each comprise a control signal receiver 1901-1904 and a control signal transmitter 2001-2004. The input terminals of the control signal receivers 1901-1904 are connected to the WDM coupler 1802, 1804, 1806, and 1808, respectively, and the output terminals of the control signal transmitters 2001-2004 are connected to the couplers 1801, 1803, 1805, and 1807, respectively. The control signal receivers 1901-1904 receive control signals from the control node 1601 and the control signal transmitters

2001-2004 transmit control signals to the control node 1601.

[0136]

The transmission/reception parts 2501-2504 each comprise a transmitter 901-904 having a wavelength tunable light source, a monitor photodetector (termed monitor PD hereafter) 2201-2204, and a receiver 1201-1204 having a wavelength tunable filter 1501-1504.

[0137]

The output terminals of the transmitters 901-904 are connected to the WDM couplers 1801, 1803, 1805, and 1807 and the monitor PDs 2201-2204 via splitters 2101-2104, respectively. The input terminals of the receivers 1201-1204 are connected to the WDM couplers 1802, 1804, 1806, and 1808 via the wavelength tunable filters 1501-1504 , respectively.

[0138]

The WDM couplers 1801, 1803, 1805, and 1807 are connected to the control signal receiver 1905-1908 and the input ports 201-204 of the wavelength routing device 101 via the WDM couplers 1809-1812, respectively.

[0139]

The control node 1601 has four control transmission/reception parts 1705-1708 and a control part 1602 thereof. The control transmission/reception parts 1705-1708 each comprise a control signal receiver 1905-1908 and a control signal transmitter 2005-2008.

[0140]

The output terminals of the control transmission/reception parts 1705-1708 each are connected to one of the input terminals of the WDM couplers 1813-1816. The other input terminals of the WDM couplers 1813-1816 are connected to the output ports 301-304 of the wavelength routing device 101, respectively. The output terminals of the WDM couplers 1813-1816 are connected to the input terminals of the WDM couplers 1802, 1804, 1806, and 1808, respectively.

[0141]

The wavelength routing device 101 outputs signal light received at the input ports 201, 202, 203, and 204 from the output ports 302, 303, 304, and 301, respectively.

[0142]

The optical communication network system having the configuration above uses light of a 1.5 micron wavelength band as actual signals 2301-2308 transmitted/received by the communication terminal nodes 701-704. On the other hand, light of a different wavelength from the communication wavelength band (1.5 micron), for example, a 1.3 micron wavelength band, is used as the control signals 2401-2408 for network control.

[0143]

Actual signals 2301-2304 and control signals 2401-2404 transmitted from the communication terminal nodes 701-704 are sent to the wavelength routing device 101 after they are multiplexed by the WDM couplers 1801, 1803, 1805, and 1807 provided at the communication terminal nodes 701-704. The actual signals 2301-2304 and control signals 2401-2404 directed to the wavelength routing device 101 are de-multiplexed by the WDM couplers 1809-1812 before they

reach the wavelength routing device 101. The actual signals 2301-2304 are introduced into the input ports 201-204 of the wavelength routing device 101 and the control signals 2401-2404 are introduced into the control transmission/reception parts 1905-1908 at the control node 1601 for controlling the communication states of the communication terminal nodes 701-704.

[0144]

The communication terminal nodes 701-704 are provided with the monitor PDs 2201-2204, respectively. Part of the light transmitted from the transmitters 901-904 each having a wavelength tunable light source at the communication terminal nodes 701-704 is introduced into the monitor PDs 2201-2204 via the splitters 2101-2104, whereby the light conditions of the transmitted actual signals 2301-2304 can be monitored.

[0145]

The control node 1601 transmits control signals 2405-2408 of 1.3 micron band light to the communication terminals 701-704. The control signals 2405-2408 and actual signals 2304, 2301, 2302, 2303 from the output ports 301-304 of the wavelength routing device 101 are multiplexed by the WDM couplers 1813-1816 and sent to the communication terminals 701-704.

[0146]

The actual signals 2301-2304 and control signals 2405-2508 received by the communication terminal nodes 701-704 are again de-multiplexed by the WDM couplers 1802, 1804, 1806, and 1808 provided at the communication terminal nodes 701-704. The actual signals 2301-2304 are introduced into the receivers 1201-1204 via the wavelength tunable filters 1501-1504. The control signals 2405-2408 are introduced into the control transmission/reception parts 1701-1704 provided at the communication terminal nodes 701-704.

[0147]

With this configuration, the control over states of the communication terminal nodes 701-704, network topology changes, and addition or removal of communication terminal nodes can be consolidated on the control node 1601. The 1.3 micron band wavelength is used as the light wavelength for control signals 2401-2408. However, any wavelength can be used as long as it can be separated from the light wavelength of actual signals. Furthermore, in this embodiment, the control signals 2405-2408 are transmitted/received through the same optical fibers as the actual signals 2301-2304. The control signals 2405-2408 can be transmitted/received through different optical fibers from those optical fibers or another communication path such as Internet.

[0148]

The wavelength distributions shown in the above embodiments are not restrictive and the wavelength distribution is determined according to which input/output port of the wavelength routing device 101 the connection is made. Needless to say, any wavelength distribution is available.

[0149]

[Effects of the Invention]

As described above, according to the optical communication system of the present invention, the network structure can be changed or communication terminal nodes can be added simply by

changing the signal light wavelengths or using additional signal light wavelengths. This is economically advantageous. Furthermore, the present invention advantageously allows a variety of logical network topologies overlapped on a physically simple network with substantial security.

[Brief Description of the Drawings]

[Fig.1] An illustration showing the physical topology of an optical communication network system according to Embodiment 1 of the present invention.

[Fig.2] A diagram showing the connection between the wavelength routing device and communication terminal nodes using twin-core optical fibers in the optical communication system of Embodiment 1 of the present invention.

[Fig.3] A diagram showing the connection between the wavelength routing device and communication terminal nodes using single-core optical fibers in the optical communication system of Embodiment 1 of the present invention.

[Fig.4] An illustration for explaining a star (mesh) network topology in the optical communication system of Embodiment 1 of the present invention.

[Fig.5] An illustration for explaining a ring network topology in the optical communication system of Embodiment 1 of the present invention.

[Fig.6] An illustration for explaining the wavelength distribution for a star (mesh) network topology in the optical communication system of Embodiment 1 of the present invention

[Fig.7] An illustration for explaining the wavelength distribution for a ring network topology in the optical communication system of Embodiment 1 of the present invention.

[Fig.8] An illustration for explaining the initial physical structure of the optical communication network system of Embodiment 2 of the present invention.

[Fig.9] An illustration for explaining the extended physical structure of the optical communication network system of Embodiment 2 of the present invention.

[Fig.10] An illustration for explaining the extended logical structure of the optical communication network system of Embodiment 2 of the present invention.

[Fig.11] An illustration for explaining the physical structure of the optical communication network system of Embodiment 3 of the present invention.

[Fig.12] An illustration for explaining the logical structure of the optical communication network system of Embodiment 3 of the present invention.

[Fig.13] An illustration for explaining the logical structure of the optical communication network system of Embodiment 3 of the present invention in detail.

[Fig.14] An illustration for explaining the wavelength distribution of the optical communication network system of Embodiment 3 of the present invention

[Fig.15] An illustration for explaining the logical structure of the optical communication network system of Embodiment 4 of the present invention.

[Fig.16] An illustration for explaining the wavelength distribution of the optical communication network system of Embodiment 4 of the present invention.

[Fig.17] An illustration for explaining the logical structure of the optical communication

network system of Embodiment 5 of the present invention.

[Fig.18] An illustration for explaining the wavelength distribution of the optical communication network system of Embodiment 5 of the present invention.

[Fig.19] An illustration for explaining the physical structure of the optical communication network system of Embodiment 6 of the present invention.

[Fig.20] An illustration for explaining the logical structure and wavelength distribution of the optical communication network system of Embodiment 6 of the present invention.

[Fig.21] An illustration showing an example of the physical structure of the optical communication network system of Embodiment 6 of the present invention when a failure occurs.

[Fig.22] An illustration showing an example of the physical structure of the optical communication network system of Embodiment 6 of the present invention when a failure occurs.

[Fig.23] An illustration showing an example of the physical structure of the optical communication network system of Embodiment 6 of the present invention when a failure occurs.

[Fig.24] An illustration for explaining the physical structure of the optical communication network system of Embodiment 7 of the present invention.

[Fig.25] An illustration for explaining the wavelength distribution of the optical communication network system of Embodiment 7 of the present invention.

[Fig.26] An illustration for explaining the physical structure of the optical communication network system of Embodiment 8 of the present invention.

[Fig.27] An illustration for explaining the physical structure of the optical communication network system of Embodiment 9 of the present invention.

[Fig.28] An illustration for explaining the physical structure of the optical communication network system of Embodiment 10 of the present invention.

[Fig.29] An illustration for explaining the physical structure of the optical communication network system of Embodiment 11 of the present invention.

[Fig.30] An illustration for explaining the logical structure of the optical communication network system of Embodiment 11 of the present invention.

[Fig.31] An illustration for explaining the physical structure of the optical communication network system of Embodiment 12 of the present invention.

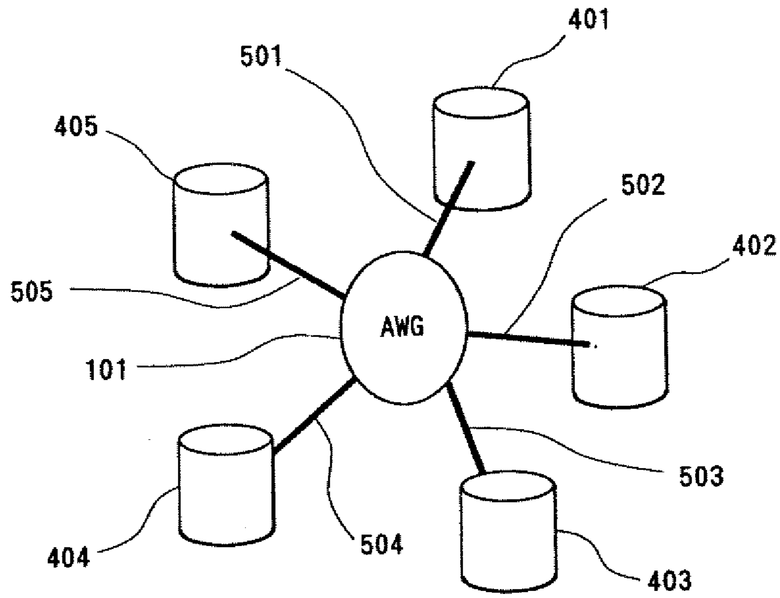
[Fig.32] An illustration for explaining the physical structure of the optical communication network system of Embodiment 13 of the present invention.

[Reference Numbers]

101, 102 ... waveguide routing device; 201-208 ... input port; 301-308 ... output port; 401-405 ...communication terminal node; 501-516 ... optical fiber; 601-616 ... signal light; 700a ... WDM-IF; 700b, 700c ... MAC; 701-714 ... communication terminal node; 801-808 ... single-core optical fiber; 901-908 ... transmitter with wavelength tunable light source or multi-wavelength light source array; 1001-1016 ... non-reciprocal circuit (optical circulator); 1101-1104 ... transmitter; 1201-1204 ... receiver; 1401-1404 ... optical DEMUX device; 1501-1508 ... transceiver; 1601 ... control node; 1701-1708 ... control transmission/reception part; 1801-1816 ... WDM coupler; 1901-1908 ... control receiver; 2001-2008 ... control transmitter; 2101-2104 ...

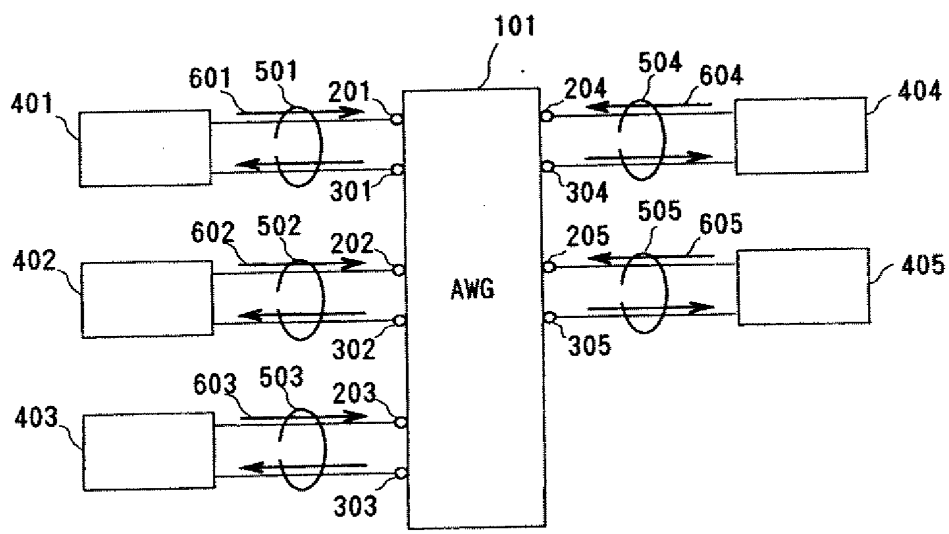
de-multiplexer; 2201-2204 ... monitor PD; 2301-2308 ... actual signal; 2401-2408 ... control signal.

FIG. 1



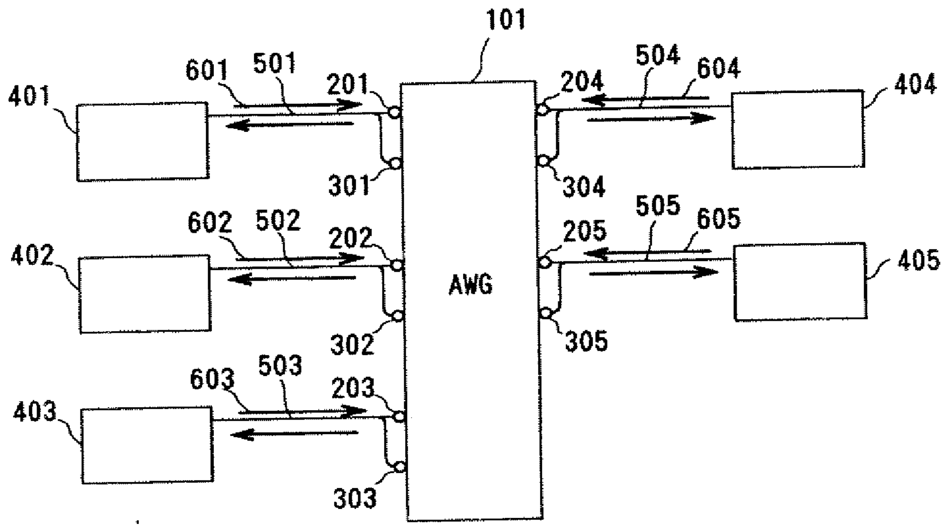
401
501
405
502
402
505
AWG
101
503
404
504
403

FIG. 2



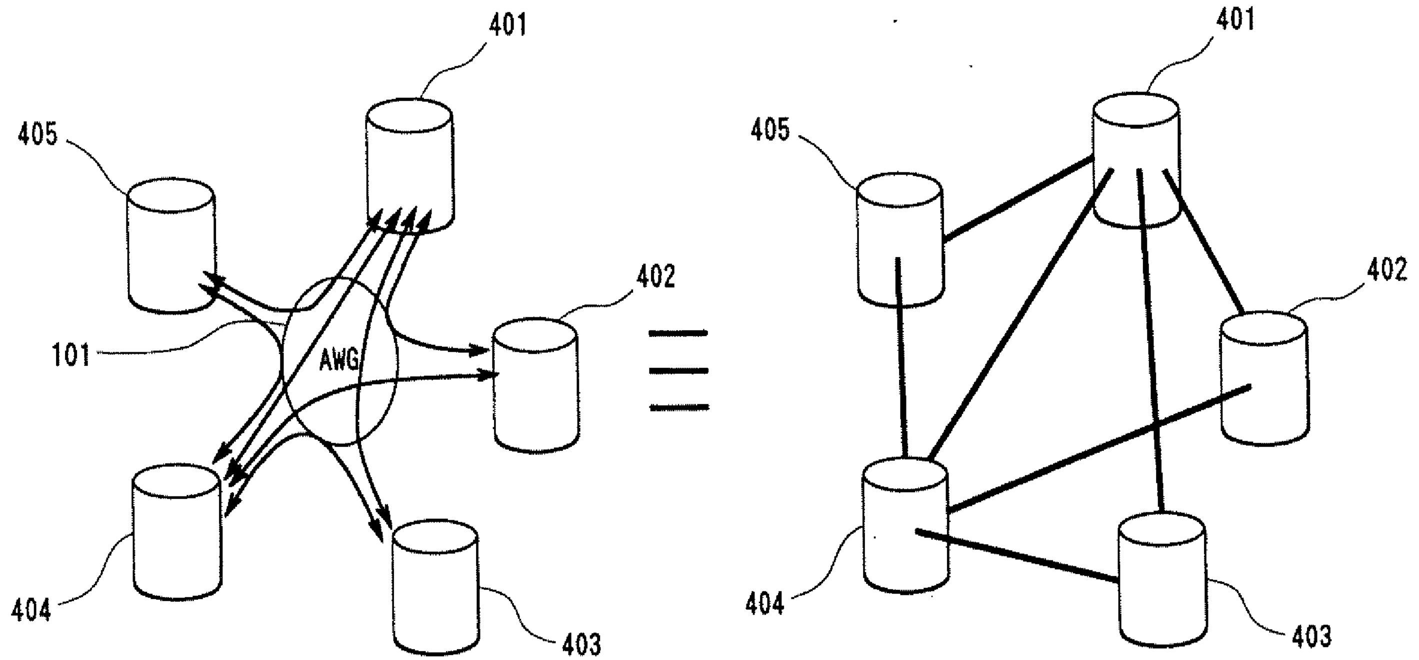
101
401
601
501
201
204
504
604
404
301
304
402
602
502
202
205
505
605
405
AWG
302
305
403
603
503
203
303

FIG. 3



101
AWG
401
402
403
404
405
601
501
201
301
602
502
202
302
603
503
203
303
204
504
604
304
205
505
605
305

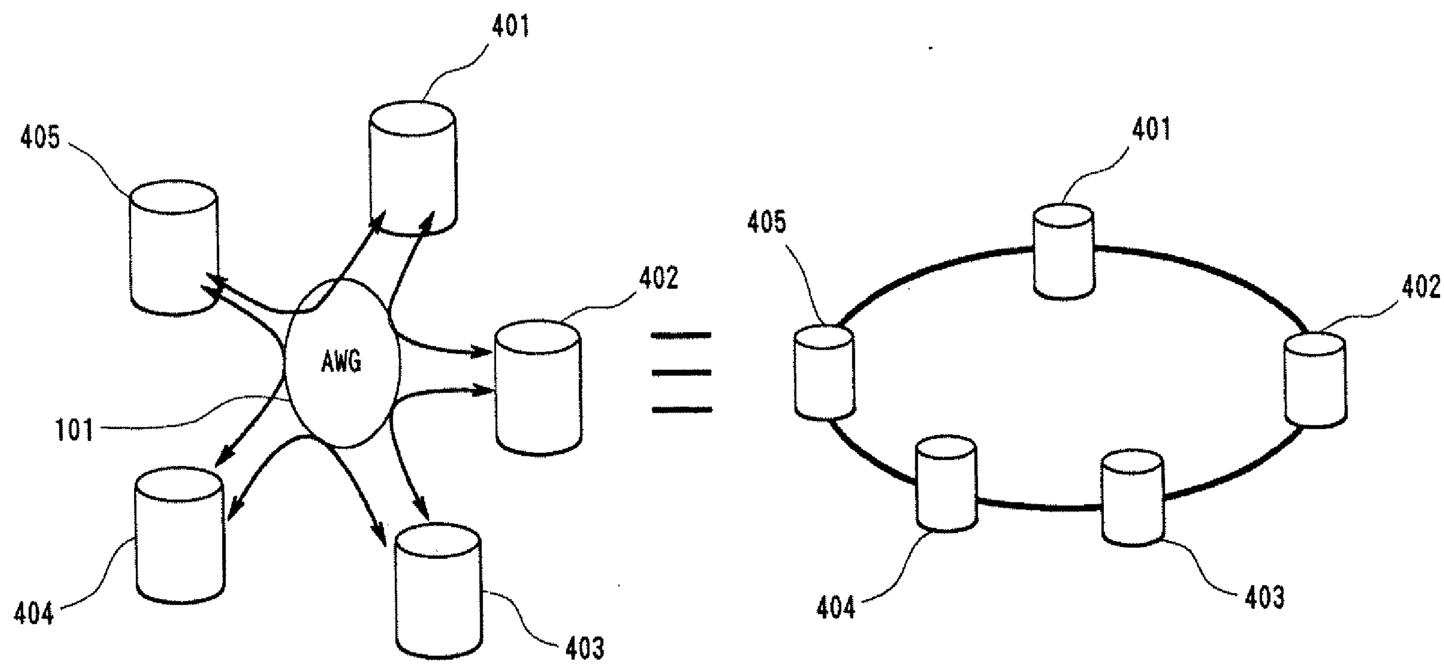
FIG. 4



SIGNAL TRANSFER PATH IMAGE
(WAVELENGTH PATH)

LOGICAL TOPOLOGY STRUCTURE OF SIGNAL PATHS

FIG. 5



SIGNAL TRANSFER PATH IMAGE
(WAVELENGTH PATH)

LOGICAL TOPOLOGY STRUCTURE OF SIGNAL PATHS

FIG. 6

OUTPUT PORT

INPUT PORT	301	302	303	304	305
201	λ1	λ2	λ3	λ4	λ5
202	λ5	λ1	λ2	λ3	λ4
203	λ4	λ5	λ1	λ2	λ3
204	λ3	λ4	λ5	λ1	λ2
205	λ2	λ3	λ4	λ5	λ1

WAVELENGTH DISTRIBUTION FOR REALIZING A STAR(MESH) TOPOLOGY

FIG. 7

OUTPUT PORT

INPUT PORT	301	302	303	304	305
201	λ1	λ2	λ3	λ4	λ5
202	λ5	λ1	λ2	λ3	λ4
203	λ4	λ5	λ1	λ2	λ3
204	λ3	λ4	λ5	λ1	λ2
205	λ2	λ3	λ4	λ5	λ1

WAVELENGTH DISTRIBUTION FOR REALIZING A RING TOPOLOGY

FIG. 8

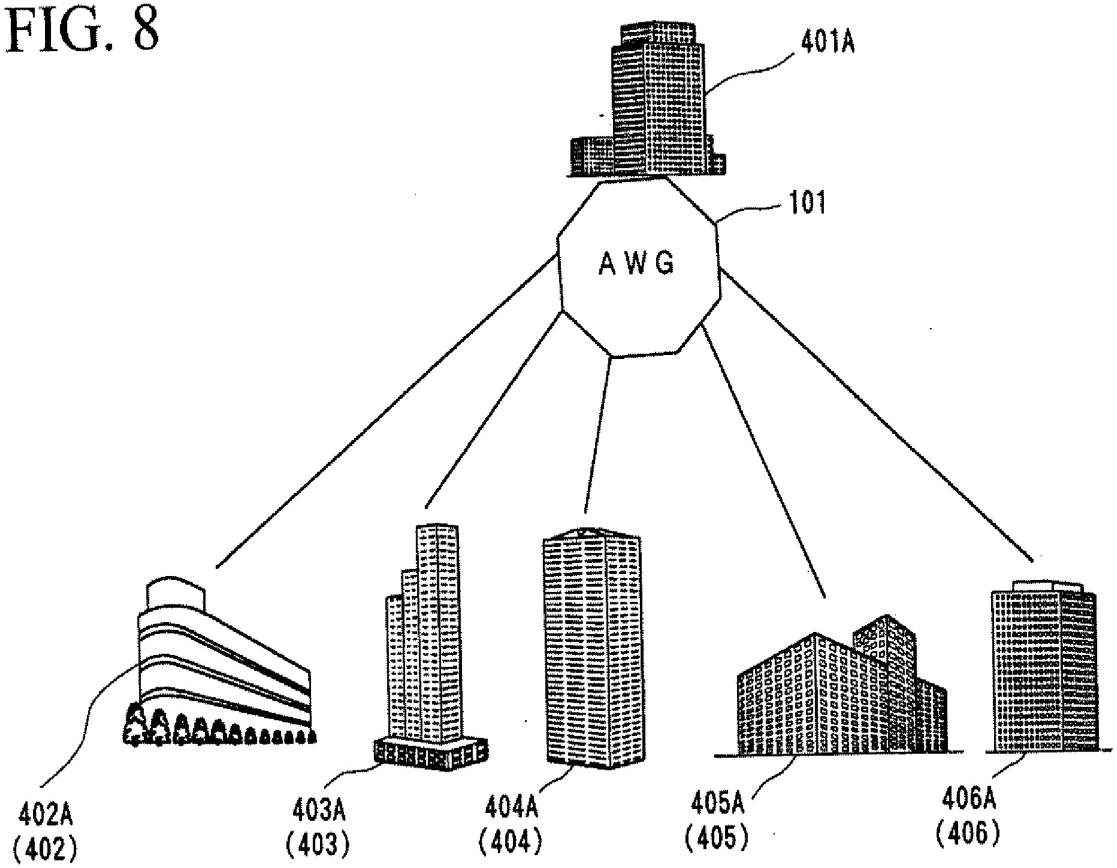


FIG. 9

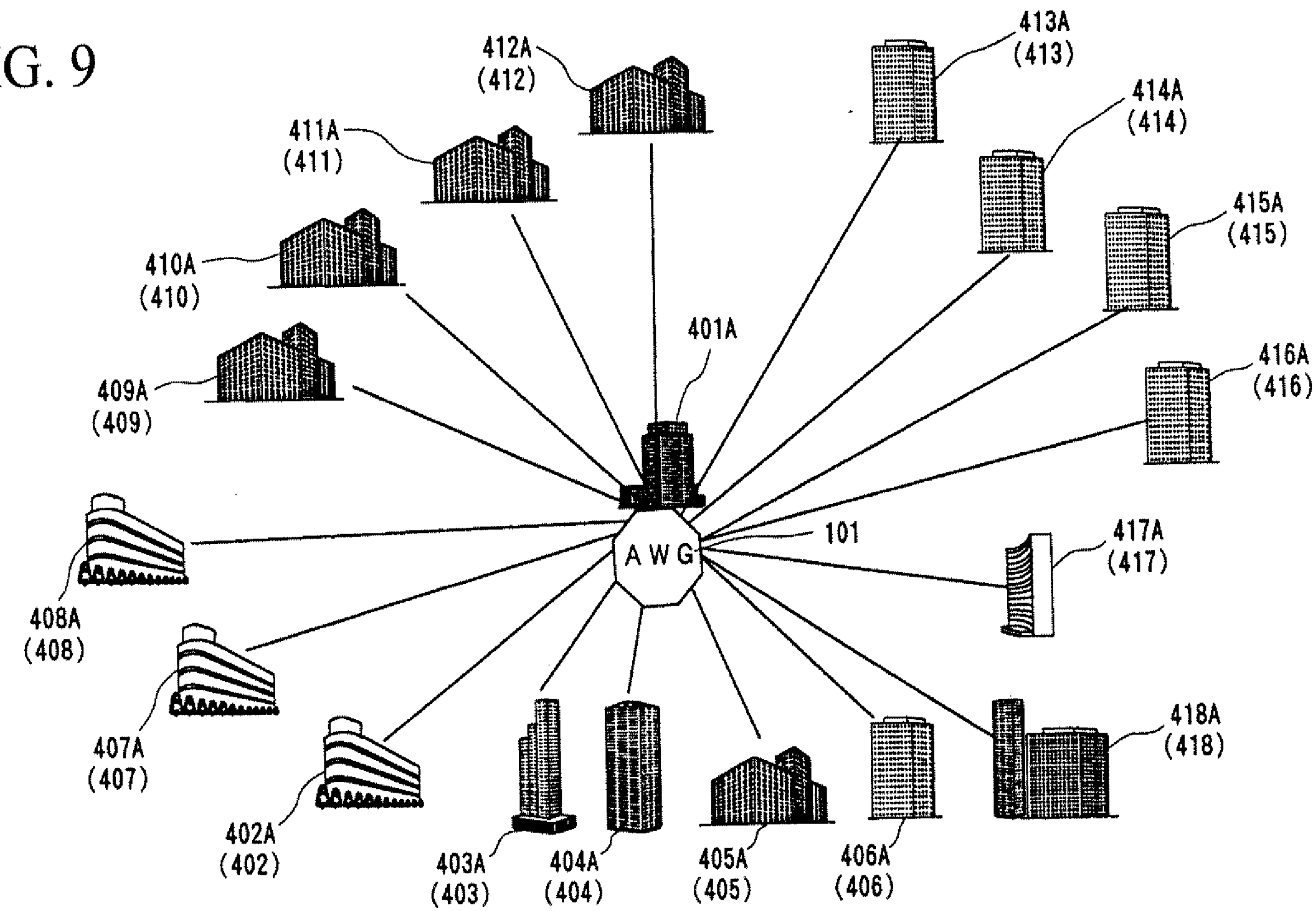

A W G
101
401A
402A
(402)
403A
(403)
404A
(404)
405A
(405)
406A
(406)
407A
(407)
408A
(408)
409A
(409)
410A
(410)
411A
(411)
412A
(412)
413A
(413)
414A
(414)
415A
(415)
416A
(416)
417A
(417)
418A
(418)

FIG. 10

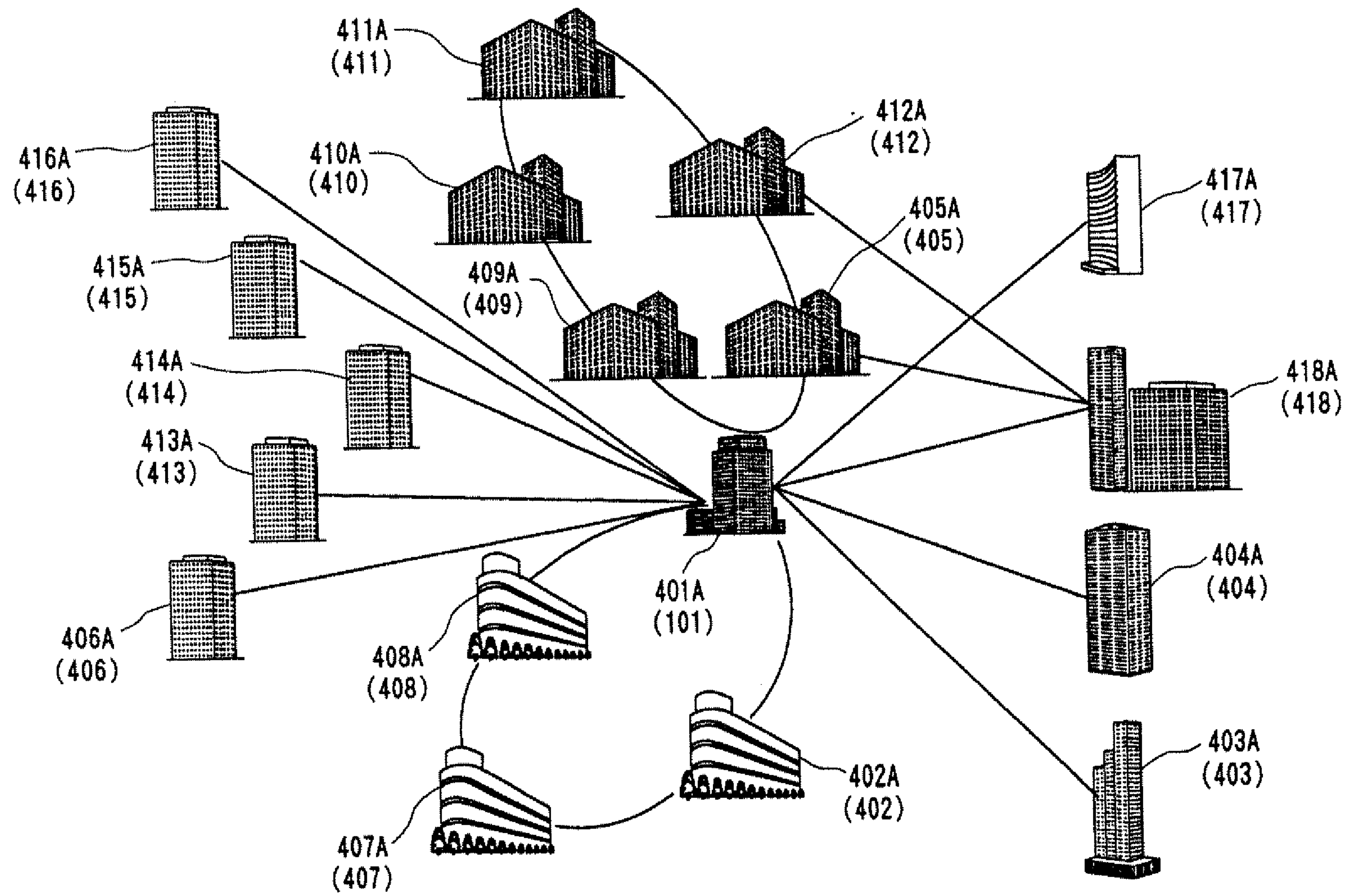
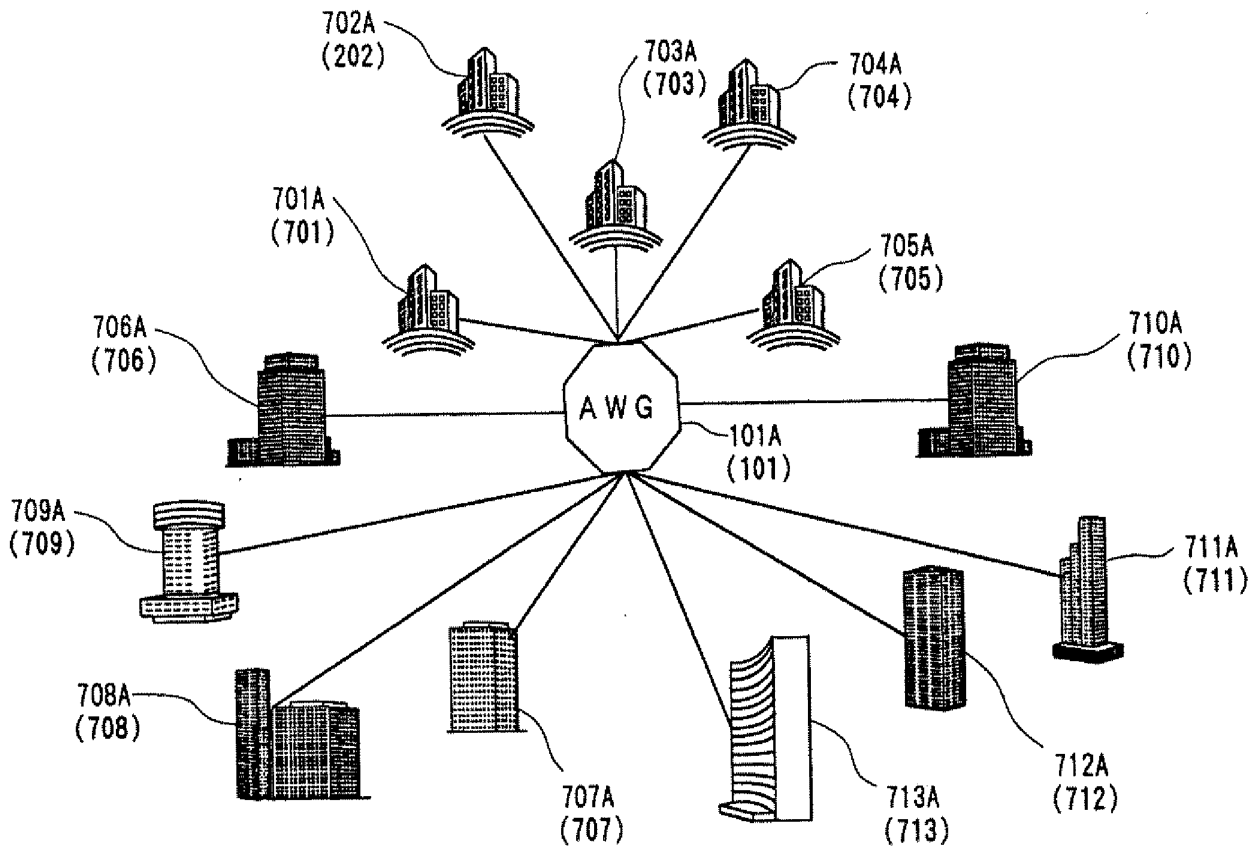

411A
(411)
412A
(412)
416A
(416)
410A
(410)
405A
(405)
417A
(417)
415A
(415)
409A
(409)
414A
(414)
418A
(418)
413A
(413)
404A
(404)
401A
(101)
406A
(406)
408A
(408)
403A
(403)
402A
(402)
407A
(407)

FIG. 11



702A
(202)
703A
(703)
704A
(704)
701A
(701)
705A
(705)
706A
(706)
AWG
101A
(101)
710A
(710)
709A
(709)
711A
(711)
708A
(708)
707A
(707)
713A
(713)
712A
(712)

FIG. 12

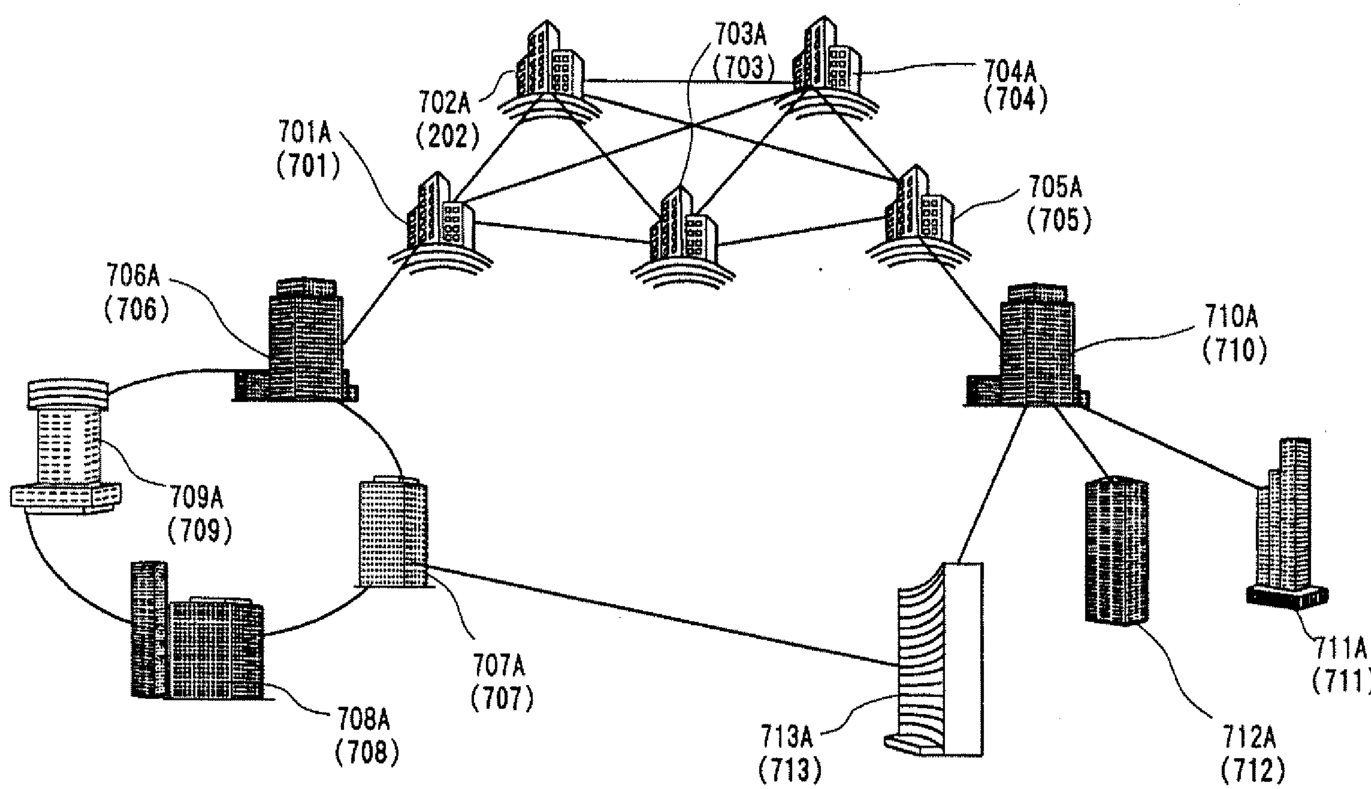

701A
(701)
702A
(202)
703A
(703)
704A
(704)
705A
(705)
706A
(706)
707A
(707)
708A
(708)
709A
(709)
710A
(710)
711A
(711)
712A
(712)
713A
(713)

FIG. 13

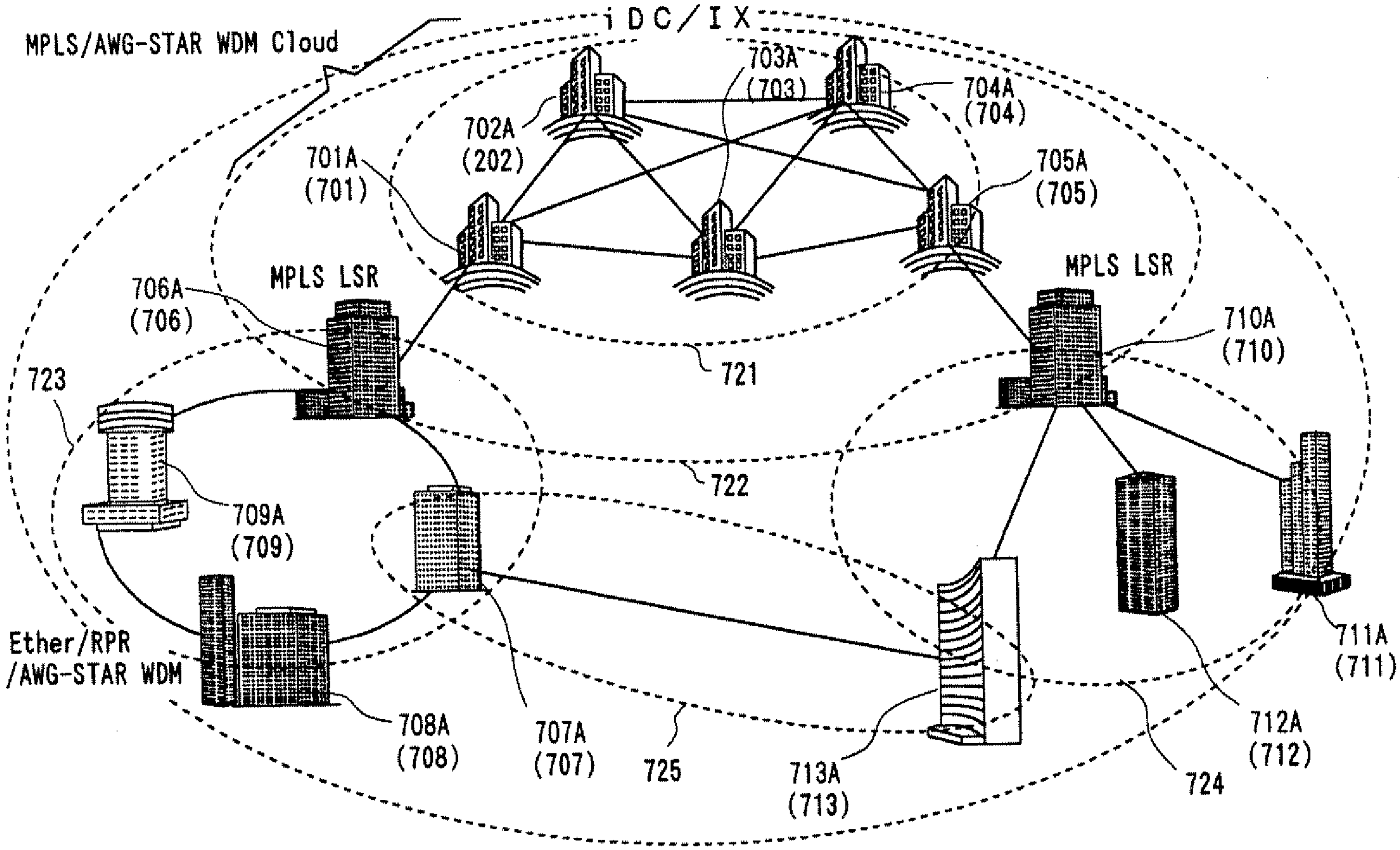

MPLS/AWG-STAR WDM Cloud
i D C / I X
701A
(701)
702A
(202)
703A
(703)
704A
(704)
705A
(705)
MPLS LSR
MPLS LSR
706A
(706)
710A
(710)
721
722
723
709A
(709)
Ether/RPR
/AWG-STAR WDM
708A
(708)
707A
(707)
725
713A
(713)
724
712A
(712)
711A
(711)

FIG. 14

722

725

OUTPUT PORT

INPUT PORT

NODE NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	λ1	λ2	λ3	λ4	λ5	λ6	λ7	λ8	λ9	λ10	λ11	λ12	λ13	λ14	λ15	λ16
2	λ2	λ3	λ4	λ5	λ6	λ7	λ8	λ9	λ10	λ11	λ12	λ13	λ14	λ15	λ16	λ1
3	λ3	λ4	λ5	λ6	λ7	λ8	λ9	λ10	λ11	λ12	λ13	λ14	λ15	λ16	λ1	λ2
4	λ4	λ5	λ6	λ7	λ8	λ9	λ10	λ11	λ12	λ13	λ14	λ15	λ16	λ1	λ2	λ3
5	λ5	λ6	λ7	λ8	λ9	λ10	λ11	λ12	λ13	λ14	λ15	λ16	λ1	λ2	λ3	λ4
6	λ6	λ7	λ8	λ9	λ10	λ11	λ12	λ13	λ14	λ15	λ16	λ1	λ2	λ3	λ4	λ5
7	λ7	λ8	λ9	λ10	λ11	λ12	λ13	λ14	λ15	λ16	λ1	λ2	λ3	λ4	λ5	λ6
8	λ8	λ9	λ10	λ11	λ12	λ13	λ14	λ15	λ16	λ1	λ2	λ3	λ4	λ5	λ6	λ7
9	λ9	λ10	λ11	λ12	λ13	λ14	λ15	λ16	λ1	λ2	λ3	λ4	λ5	λ6	λ7	λ8
10	λ10	λ11	λ12	λ13	λ14	λ15	λ16	λ1	λ2	λ3	λ4	λ5	λ6	λ7	λ8	λ9
11	λ11	λ12	λ13	λ14	λ15	λ16	λ1	λ2	λ3	λ4	λ5	λ6	λ7	λ8	λ9	λ10
12	λ12	λ13	λ14	λ15	λ16	λ1	λ2	λ3	λ4	λ5	λ6	λ7	λ8	λ9	λ10	λ11
13	λ13	λ14	λ15	λ16	λ1	λ2	λ3	λ4	λ5	λ6	λ7	λ8	λ9	λ10	λ11	λ12
14	λ14	λ15	λ16	λ1	λ2	λ3	λ4	λ5	λ6	λ7	λ8	λ9	λ10	λ11	λ12	λ13
15	λ15	λ16	λ1	λ2	λ3	λ4	λ5	λ6	λ7	λ8	λ9	λ10	λ11	λ12	λ13	λ14
16	λ16	λ1	λ2	λ3	λ4	λ5	λ6	λ7	λ8	λ9	λ10	λ11	λ12	λ13	λ14	λ15

725

724

FIG. 15

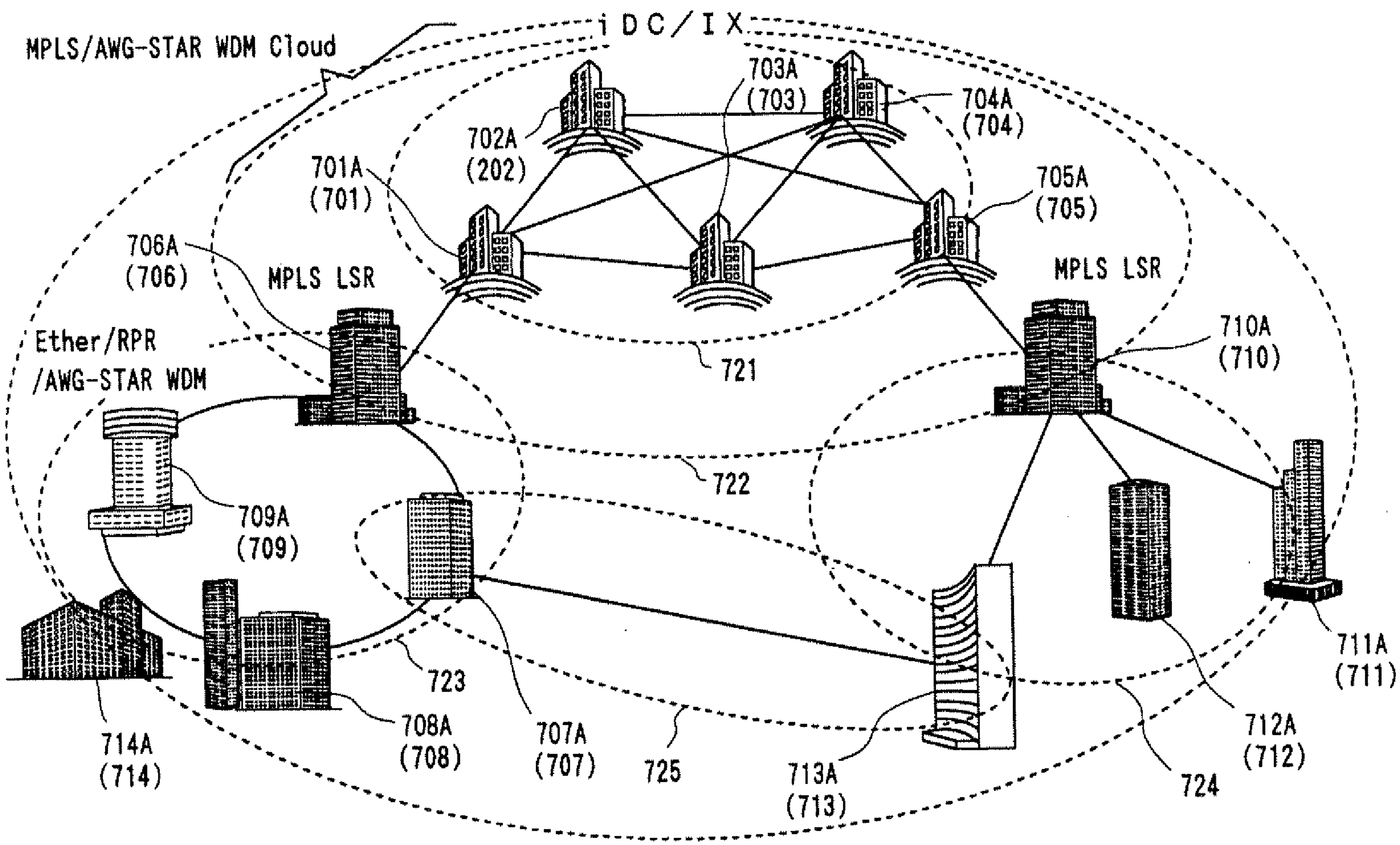

MPLS/AWG-STAR WDM Cloud
iDC/IX
701A
(701)
702A
(202)
703A
(703)
704A
(704)
705A
(705)
706A
(706)
MPLS LSR
MPLS LSR
Ether/RPR
/AWG-STAR WDM
710A
(710)
721
722
709A
(709)
723
708A
(708)
707A
(707)
725
713A
(713)
724
712A
(712)
711A
(711)
714A
(714)

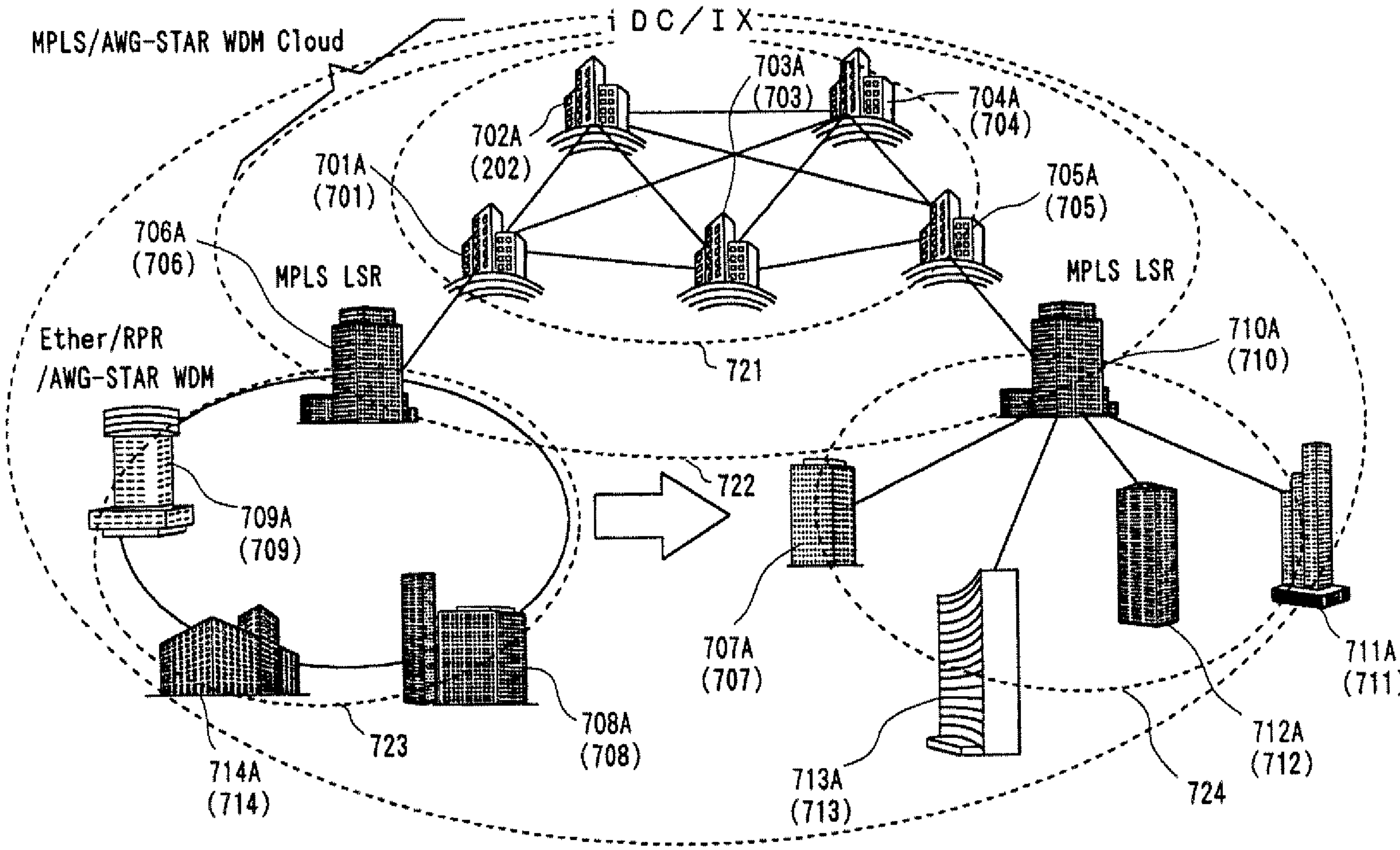
FIG. 16

OUTPUT PORT

INPUT PORT

NODE NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	λ1	λ2	λ3	λ4	λ5	λ6	λ7	λ8	λ9	λ10	λ11	λ12	λ13	λ14	λ15	λ16
2	λ2	λ3	λ4	λ5	λ6	λ7	λ8	λ9	λ10	λ11	λ12	λ13	λ14	λ15	λ16	λ1
3	λ3	λ4	λ5	λ6	λ7	λ8	λ9	λ10	λ11	λ12	λ13	λ14	λ15	λ16	λ1	λ2
4	λ4	λ5	λ6	λ7	λ8	λ9	λ10	λ11	λ12	λ13	λ14	λ15	λ16	λ1	λ2	λ3
5	λ5	λ6	λ7	λ8	λ9	λ10	λ11	λ12	λ13	λ14	λ15	λ16	λ1	λ2	λ3	λ4
6	λ6	λ7	λ8	λ9	λ10	λ11	λ12	λ13	λ14	λ15	λ16	λ1	λ2	λ3	λ4	λ5
7	λ7	λ8	λ9	λ10	λ11	λ12	λ13	λ14	λ15	λ16	λ1	λ2	λ3	λ4	λ5	λ6
8	λ8	λ9	λ10	λ11	λ12	λ13	λ14	λ15	λ16	λ1	λ2	λ3	λ4	λ5	λ6	λ7
9	λ9	λ10	λ11	λ12	λ13	λ14	λ15	λ16	λ1	λ2	λ3	λ4	λ5	λ6	λ7	λ8
10	λ10	λ11	λ12	λ13	λ14	λ15	λ16	λ1	λ2	λ3	λ4	λ5	λ6	λ7	λ8	λ9
11	λ11	λ12	λ13	λ14	λ15	λ16	λ1	λ2	λ3	λ4	λ5	λ6	λ7	λ8	λ9	λ10
12	λ12	λ13	λ14	λ15	λ16	λ1	λ2	λ3	λ4	λ5	λ6	λ7	λ8	λ9	λ10	λ11
13	λ13	λ14	λ15	λ16	λ1	λ2	λ3	λ4	λ5	λ6	λ7	λ8	λ9	λ10	λ11	λ12
14	λ14	λ15	λ16	λ1	λ2	λ3	λ4	λ5	λ6	λ7	λ8	λ9	λ10	λ11	λ12	λ13
15	λ15	λ16	λ1	λ2	λ3	λ4	λ5	λ6	λ7	λ8	λ9	λ10	λ11	λ12	λ13	λ14
16	λ16	λ1	λ2	λ3	λ4	λ5	λ6	λ7	λ8	λ9	λ10	λ11	λ12	λ13	λ14	λ15

FIG. 17



MPLS/AWG-STAR WDM Cloud
iDC/IX
701A
(701)
702A
(202)
703A
(703)
704A
(704)
705A
(705)
706A
(706)
MPLS LSR
MPLS LSR
710A
(710)
721
Ether/RPR
/AWG-STAR WDM
709A
(709)
722
707A
(707)
708A
(708)
723
714A
(714)
713A
(713)
724
712A
(712)
711A
(711)

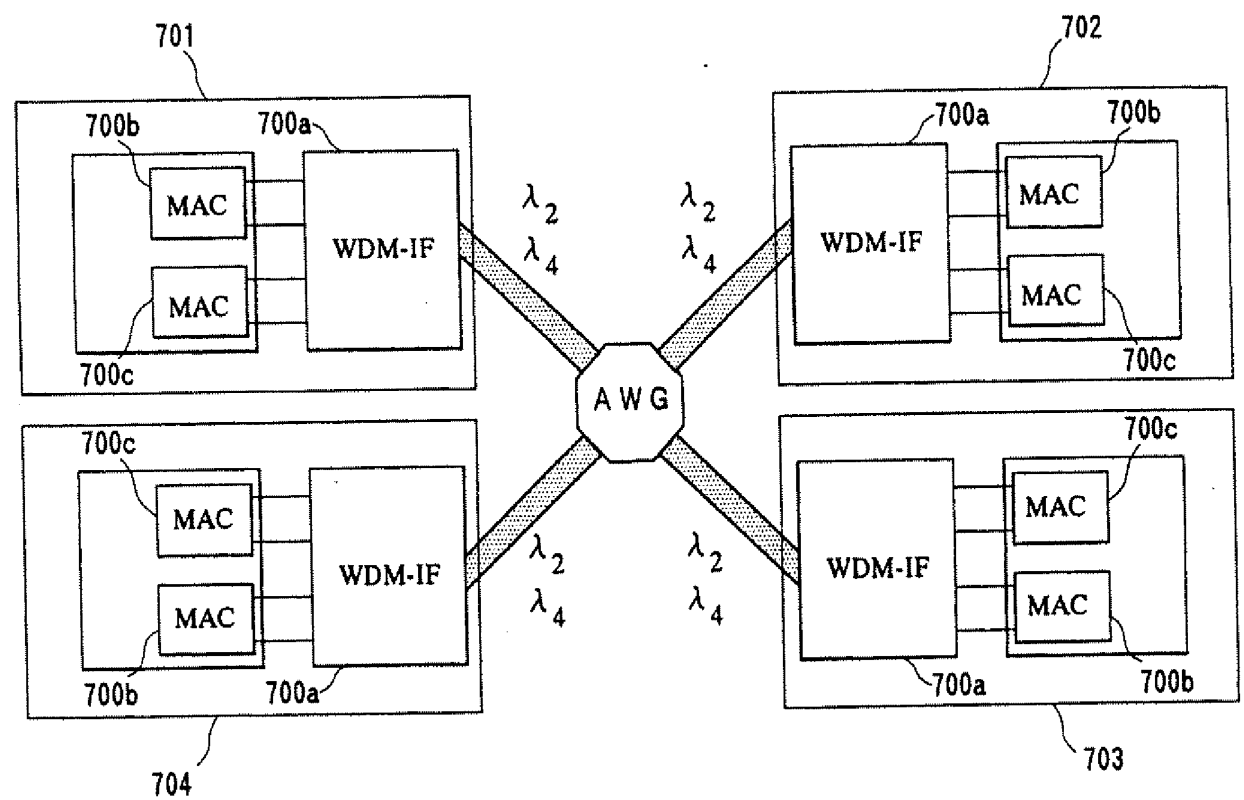
FIG. 18

OUTPUT PORT

INPUT PORT

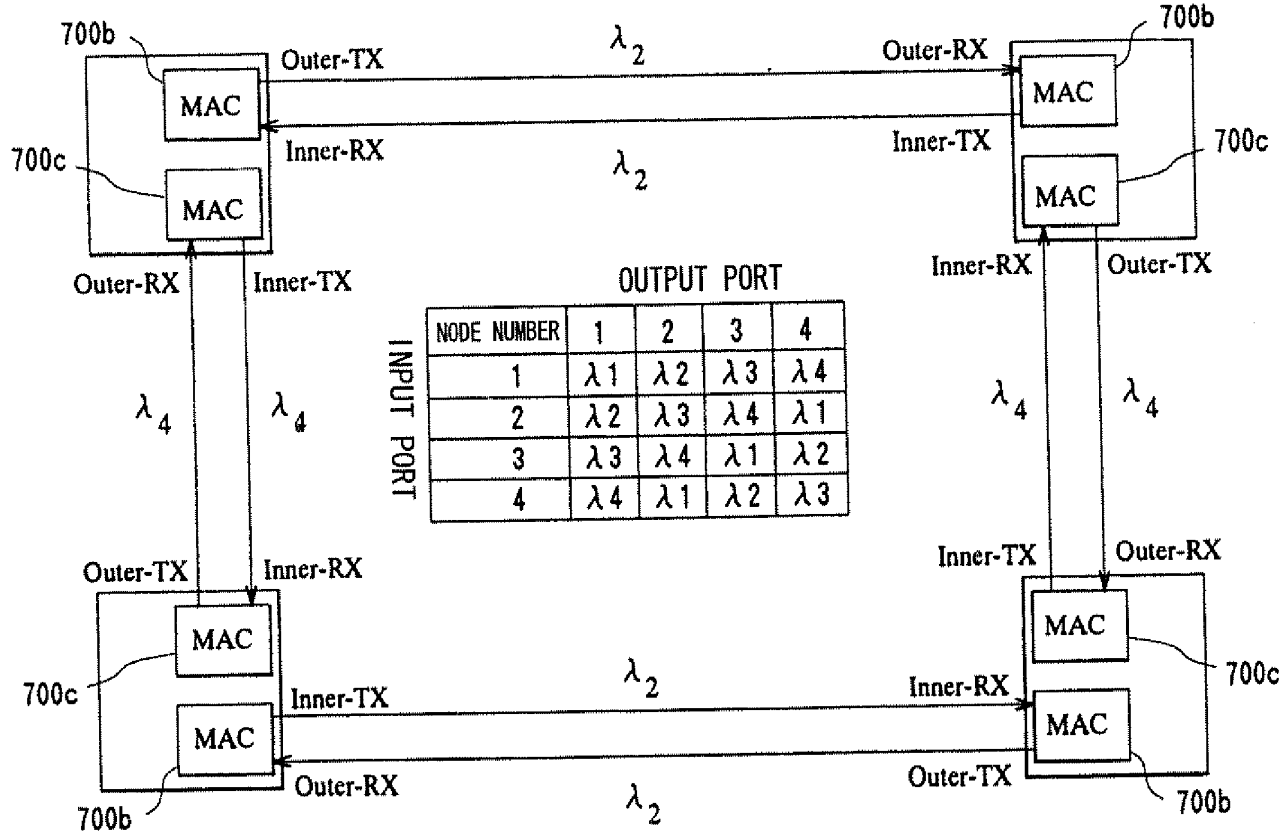
NODE NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	λ1	λ2	λ3	λ4	λ5	λ6	λ7	λ8	λ9	λ10	λ11	λ12	λ13	λ14	λ15	λ16
2	λ2	λ3	λ4	λ5	λ6	λ7	λ8	λ9	λ10	λ11	λ12	λ13	λ14	λ15	λ16	λ1
3	λ3	λ4	λ5	λ6	λ7	λ8	λ9	λ10	λ11	λ12	λ13	λ14	λ15	λ16	λ1	λ2
4	λ4	λ5	λ6	λ7	λ8	λ9	λ10	λ11	λ12	λ13	λ14	λ15	λ16	λ1	λ2	λ3
5	λ5	λ6	λ7	λ8	λ9	λ10	λ11	λ12	λ13	λ14	λ15	λ16	λ1	λ2	λ3	λ4
6	λ6	λ7	λ8	λ9	λ10	λ11	λ12	λ13	λ14	λ15	λ16	λ1	λ2	λ3	λ4	λ5
7	λ7	λ8	λ9	λ10	λ11	λ12	λ13	λ14	λ15	λ16	λ1	λ2	λ3	λ4	λ5	λ6
8	λ8	λ9	λ10	λ11	λ12	λ13	λ14	λ15	λ16	λ1	λ2	λ3	λ4	λ5	λ6	λ7
9	λ9	λ10	λ11	λ12	λ13	λ14	λ15	λ16	λ1	λ2	λ3	λ4	λ5	λ6	λ7	λ8
10	λ10	λ11	λ12	λ13	λ14	λ15	λ16	λ1	λ2	λ3	λ4	λ5	λ6	λ7	λ8	λ9
11	λ11	λ12	λ13	λ14	λ15	λ16	λ1	λ2	λ3	λ4	λ5	λ6	λ7	λ8	λ9	λ10
12	λ12	λ13	λ14	λ15	λ16	λ1	λ2	λ3	λ4	λ5	λ6	λ7	λ8	λ9	λ10	λ11
13	λ13	λ14	λ15	λ16	λ1	λ2	λ3	λ4	λ5	λ6	λ7	λ8	λ9	λ10	λ11	λ12
14	λ14	λ15	λ16	λ1	λ2	λ3	λ4	λ5	λ6	λ7	λ8	λ9	λ10	λ11	λ12	λ13
15	λ15	λ16	λ1	λ2	λ3	λ4	λ5	λ6	λ7	λ8	λ9	λ10	λ11	λ12	λ13	λ14
16	λ16	λ1	λ2	λ3	λ4	λ5	λ6	λ7	λ8	λ9	λ10	λ11	λ12	λ13	λ14	λ15

FIG. 19



701
700b
700a
MAC
WDM-IF
MAC
700c
702
700a
700b
WDM-IF
MAC
MAC
700c
AWG
λ2
λ4
λ2
λ4
λ2
λ4
λ2
λ4
700c
MAC
WDM-IF
MAC
700b
700a
704
700c
WDM-IF
MAC
MAC
700a
700b
703

FIG. 20

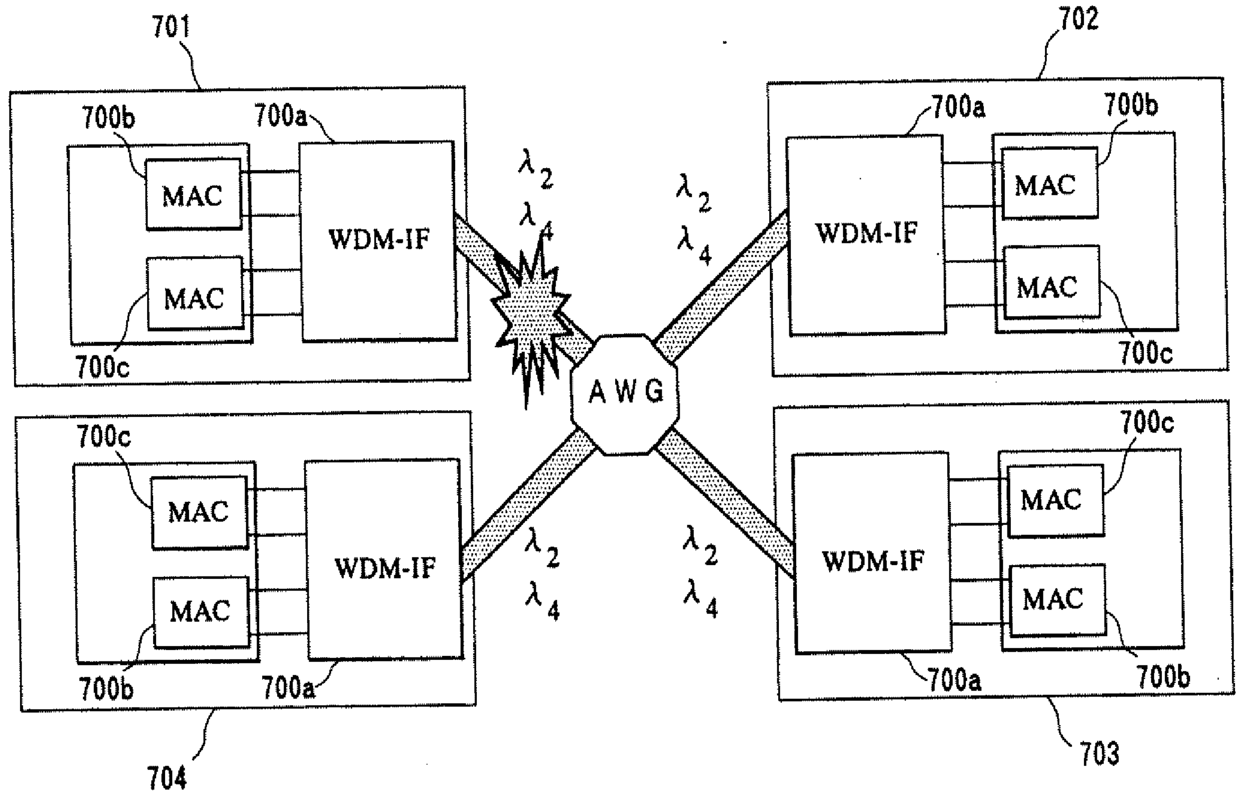


OUTPUT PORT

INPUT PORT

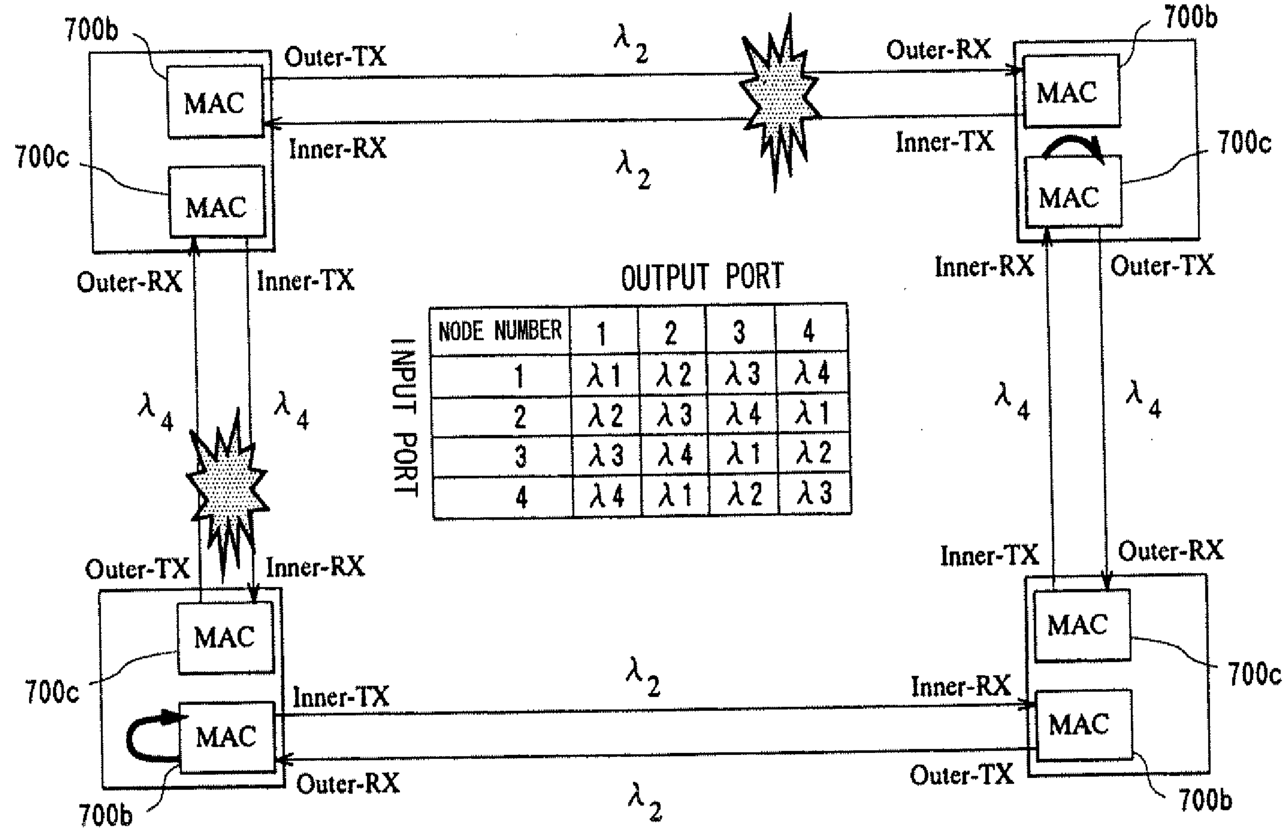
NODE NUMBER	1	2	3	4
1	$\lambda 1$	$\lambda 2$	$\lambda 3$	$\lambda 4$
2	$\lambda 2$	$\lambda 3$	$\lambda 4$	$\lambda 1$
3	$\lambda 3$	$\lambda 4$	$\lambda 1$	$\lambda 2$
4	$\lambda 4$	$\lambda 1$	$\lambda 2$	$\lambda 3$

FIG. 21



701
700b
700a
MAC
WDM-IF
MAC
700c
702
700a
700b
WDM-IF
MAC
MAC
700c
λ2
λ4
λ2
λ4
A W G
700c
MAC
WDM-IF
MAC
700b
700a
704
λ2
λ4
λ2
λ4
700c
WDM-IF
MAC
MAC
700a
700b
703

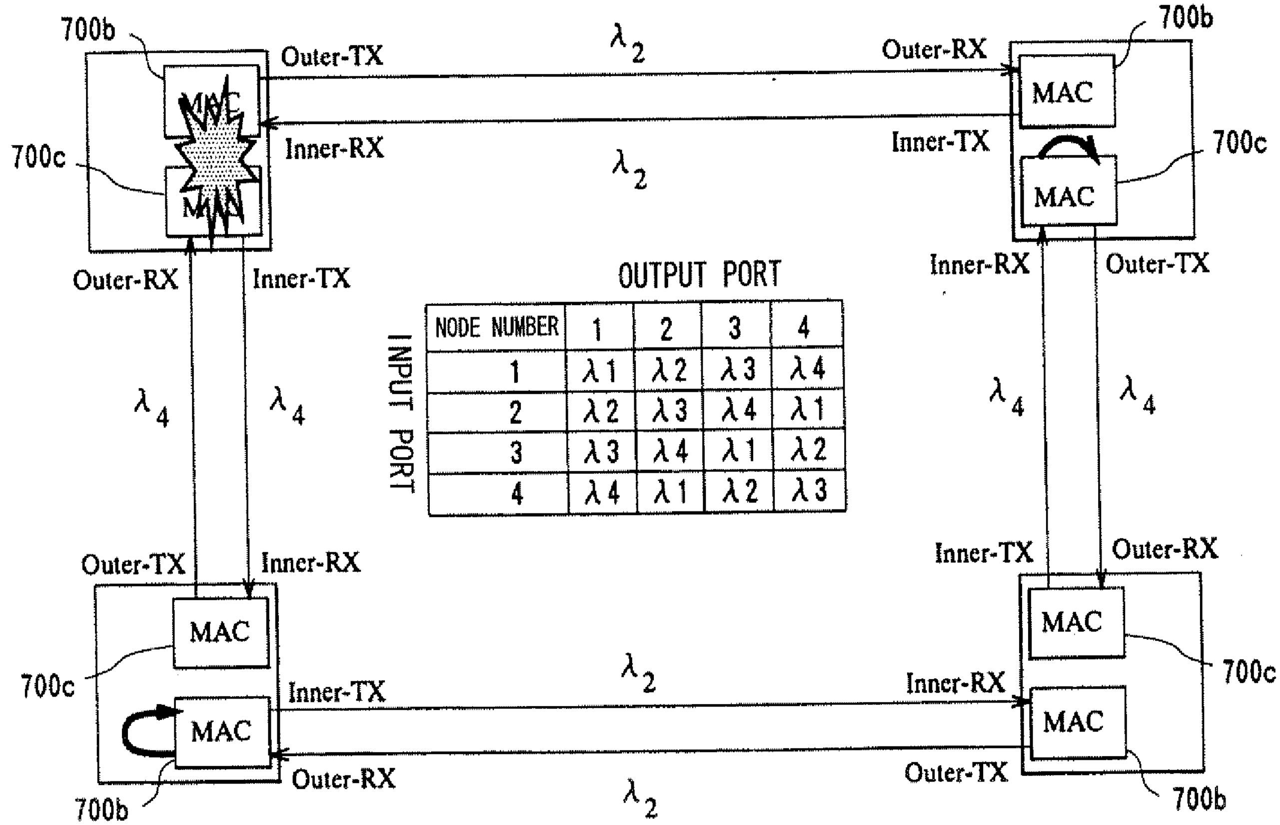
FIG. 22



700b
700c
MAC
MAC
Outer-TX
Inner-RX
Outer-RX
Inner-TX
λ_2
λ_2
λ_4
λ_4
Outer-TX
Inner-RX
Inner-TX
Outer-RX
Inner-TX
Outer-RX
Inner-RX
Outer-TX
OUTPUT PORT
INPUT PORT

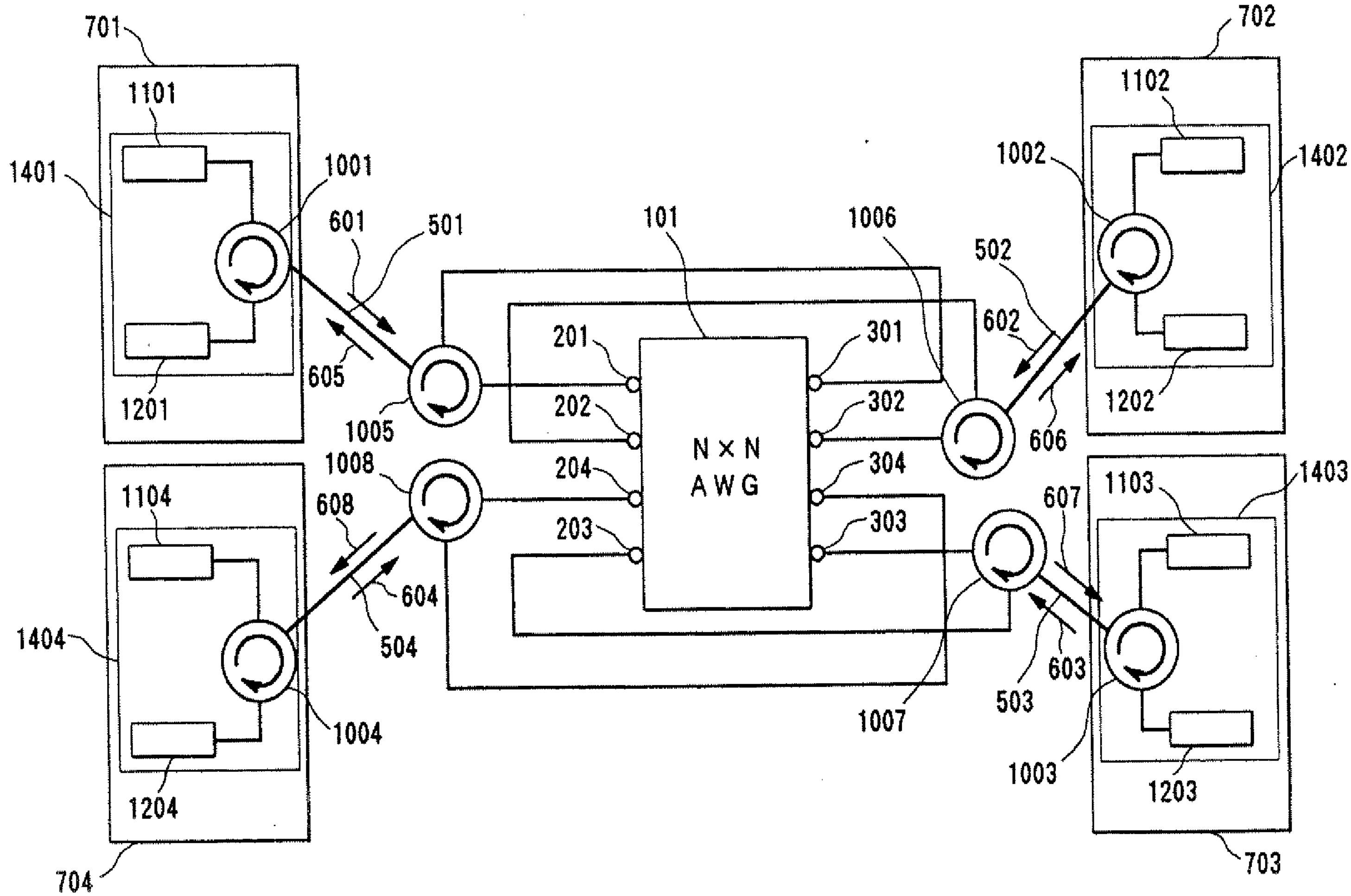
NODE NUMBER	1	2	3	4
1	λ1	λ2	λ3	λ4
2	λ2	λ3	λ4	λ1
3	λ3	λ4	λ1	λ2
4	λ4	λ1	λ2	λ3

FIG. 23



NODE NUMBER	1	2	3	4
1	λ1	λ2	λ3	λ4
2	λ2	λ3	λ4	λ1
3	λ3	λ4	λ1	λ2
4	λ4	λ1	λ2	λ3

FIG. 24



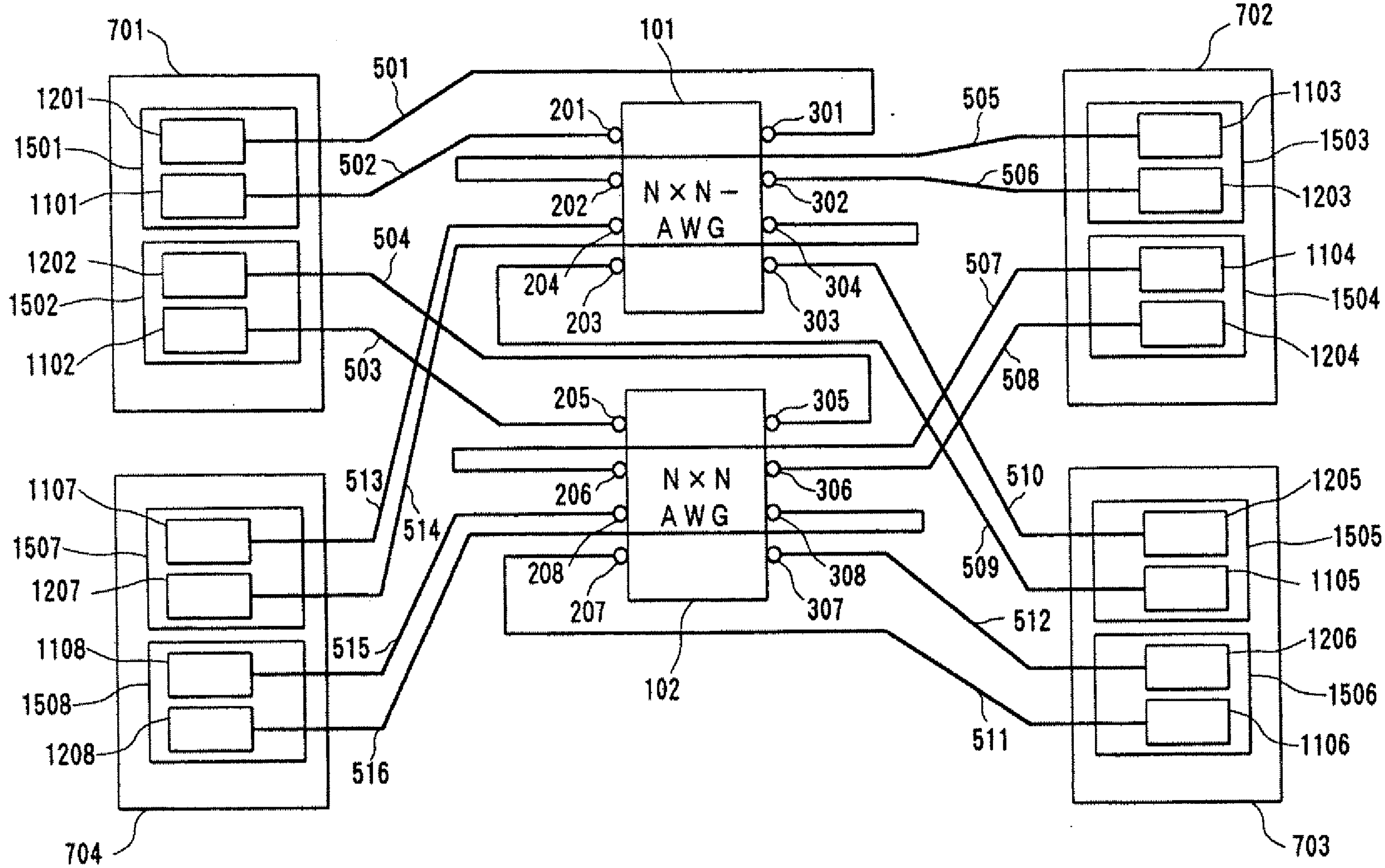
701
1101
1401
1001
601
501
605
1201
1005
101
1006
502
1002
1102
1402
602
1202
606
702
201
202
204
203
301
302
304
303
N × N
A W G
1008
1104
608
604
504
1404
1004
1204
704
1007
607
1103
1403
503
603
1003
1203
703

FIG. 25

COMMUNICATION TERMINAL (RECEPTION)

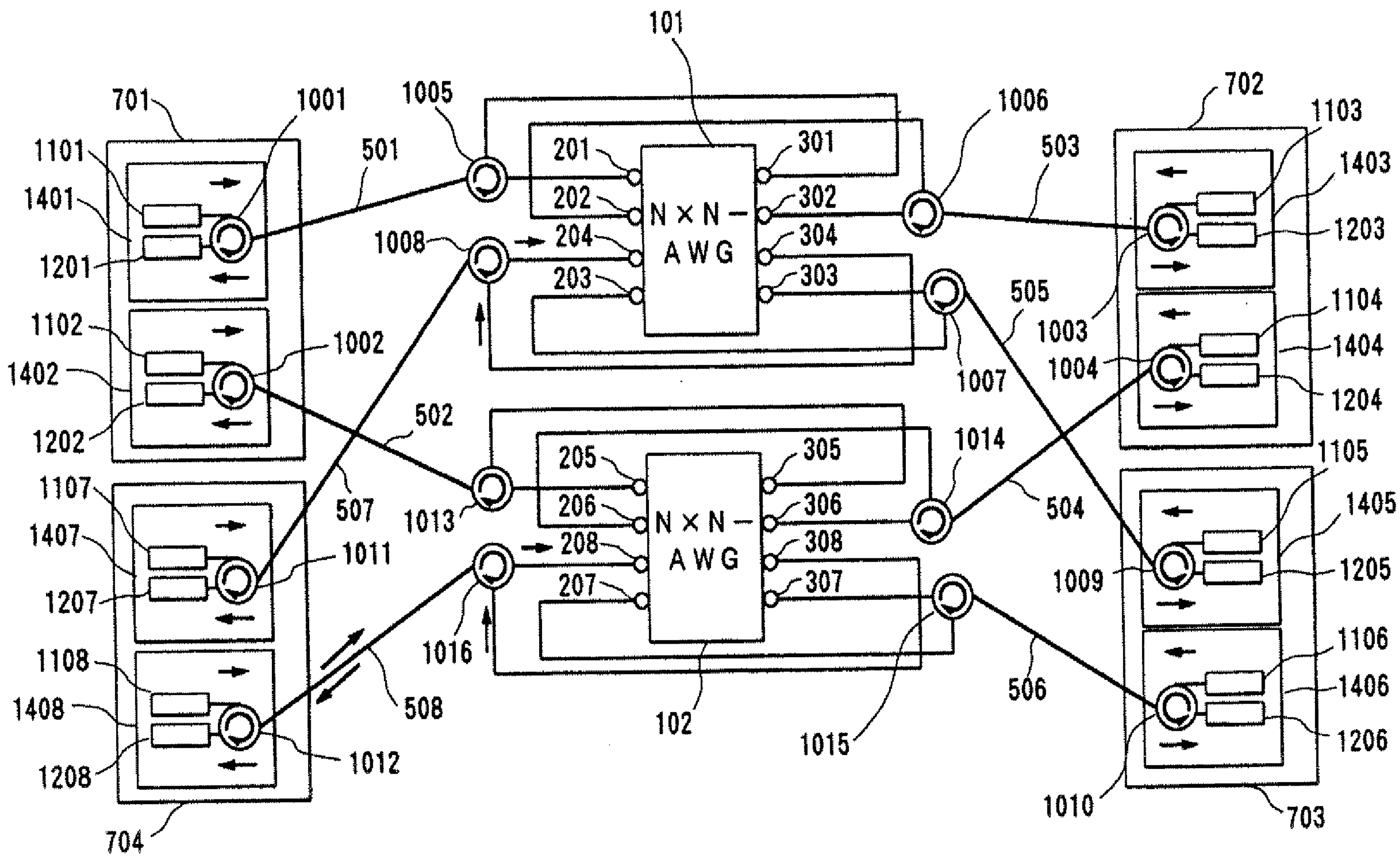
COMMUNICATION TERMINAL (TRANSMISSION)	701	702	703	704
701	λ1	λ2	λ3	λ4
702	λ4	λ1	λ2	λ3
703	λ3	λ4	λ1	λ2
704	λ2	λ3	λ4	λ1

FIG. 26



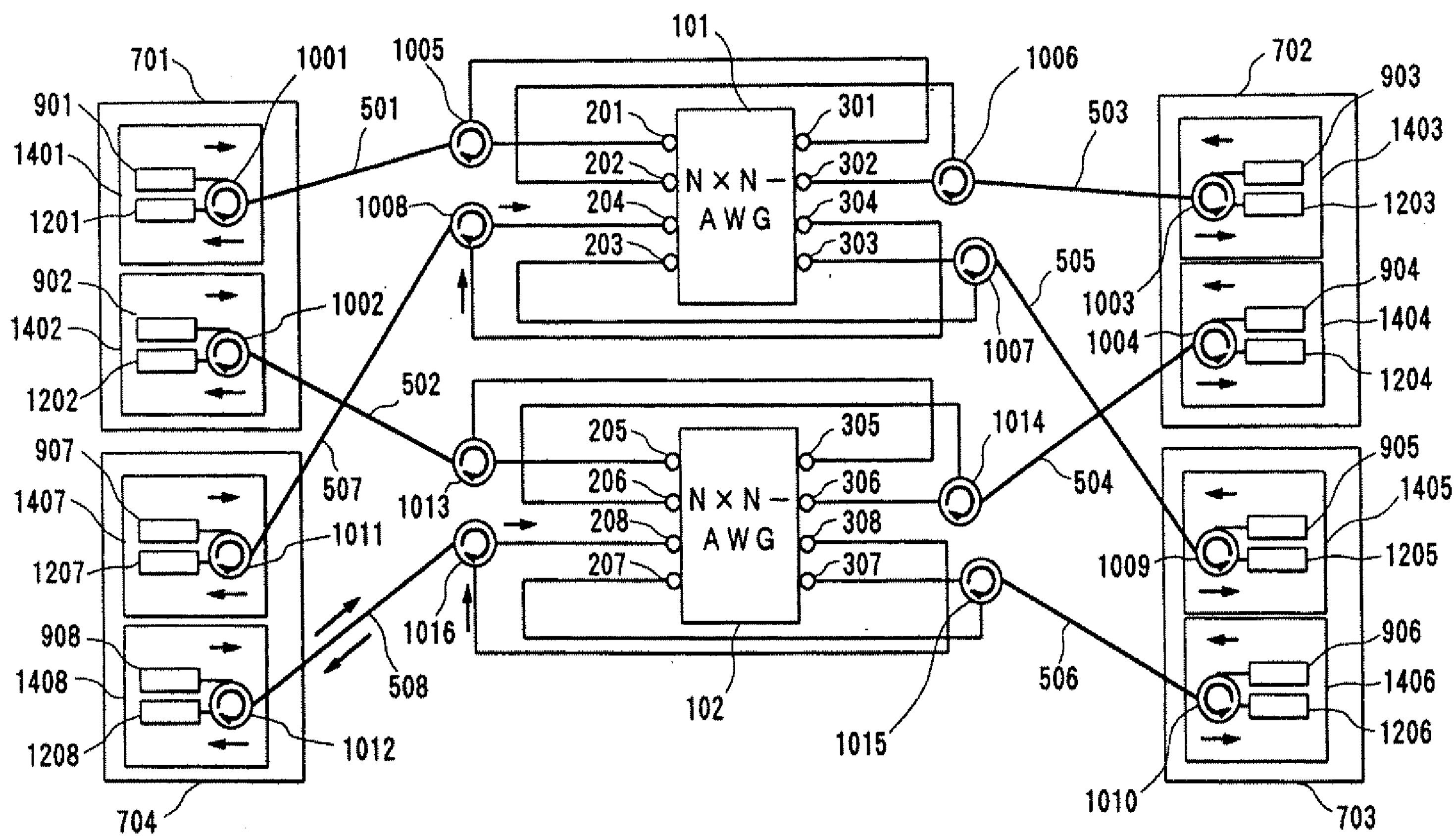
701
702
703
704
101
102
N × N – AWG
N × N AWG
201
202
203
204
205
206
207
208
301
302
303
304
305
306
307
308
501
502
503
504
505
506
507
508
509
510
511
512
513
514
515
516
1201
1501
1101
1202
1502
1102
1107
1507
1207
1108
1508
1208
1103
1503
1203
1104
1504
1204
1205
1505
1105
1206
1506
1106

FIG. 27



101
N × N − AWG
102
N × N − AWG
201
202
203
204
205
206
207
208
301
302
303
304
305
306
307
308
501
502
503
504
505
506
507
508
701
702
703
704
1001
1002
1003
1004
1005
1006
1007
1008
1009
1010
1011
1012
1013
1014
1015
1016
1101
1102
1103
1104
1105
1106
1107
1108
1201
1202
1203
1204
1205
1206
1207
1208
1401
1402
1403
1404
1405
1406
1407
1408

FIG. 28



N × N − AWG
N × N − AWG
101
102
201
202
203
204
205
206
207
208
301
302
303
304
305
306
307
308
501
502
503
504
505
506
507
508
701
702
703
704
901
902
903
904
905
906
907
908
1001
1002
1003
1004
1005
1006
1007
1008
1009
1010
1011
1012
1013
1014
1015
1016
1201
1202
1203
1204
1205
1206
1207
1208
1401
1402
1403
1404
1405
1406
1407
1408

FIG. 29

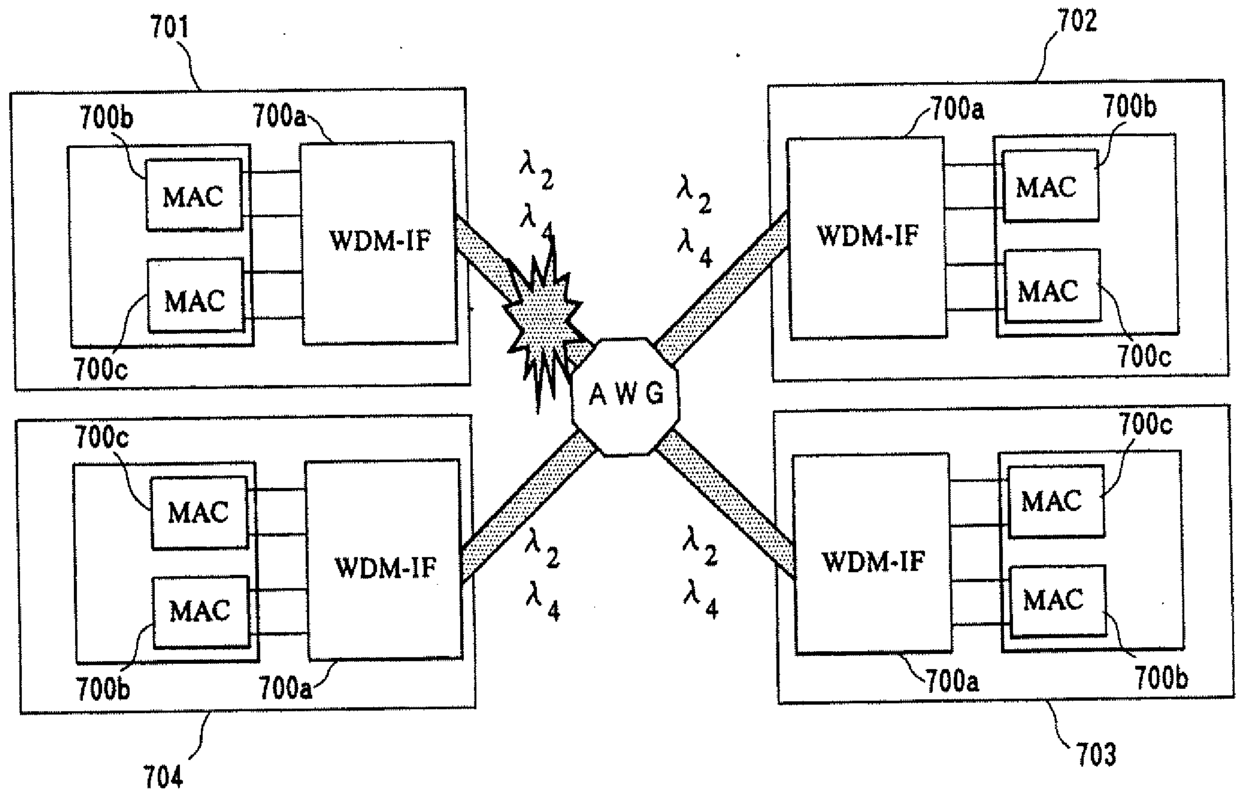
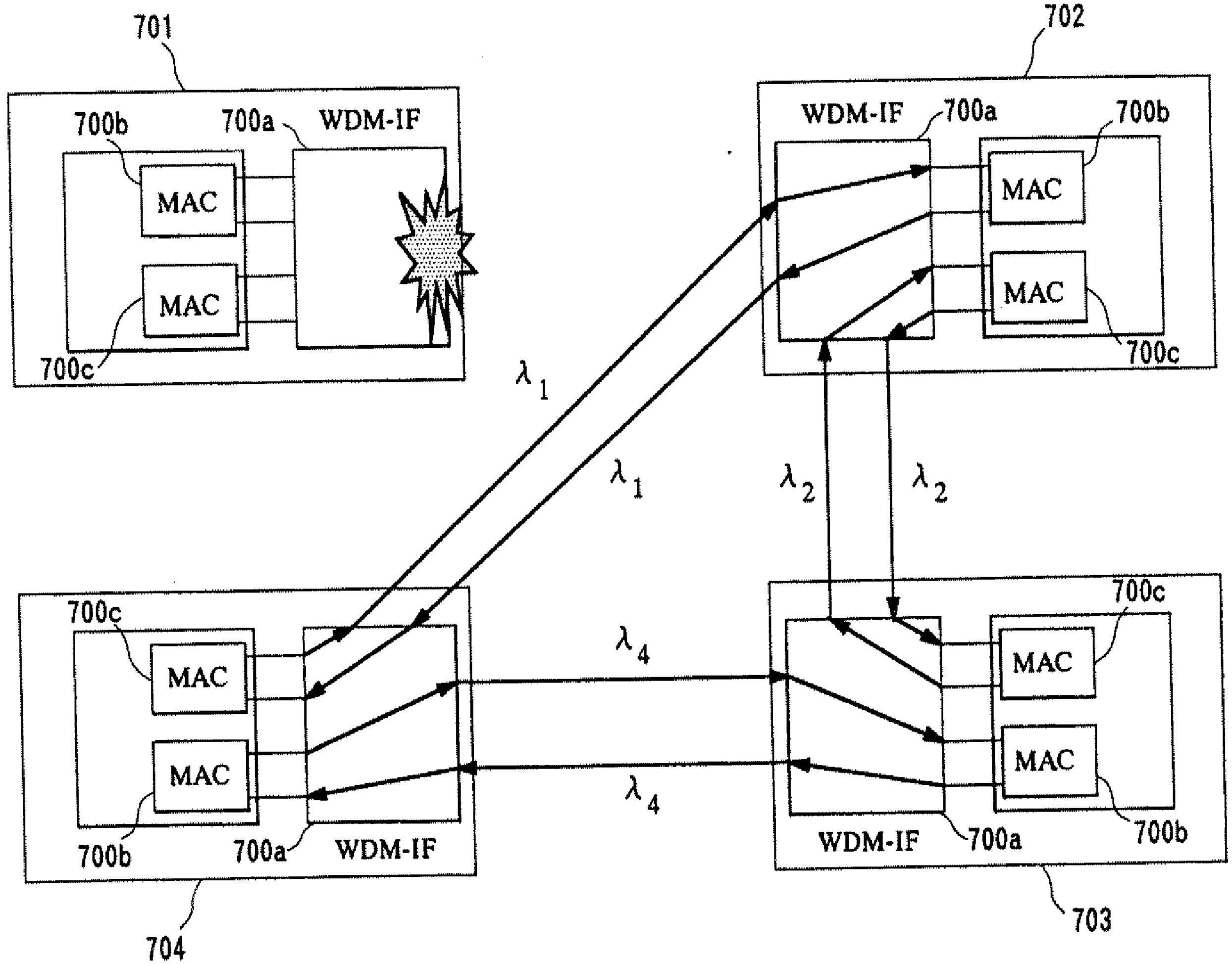
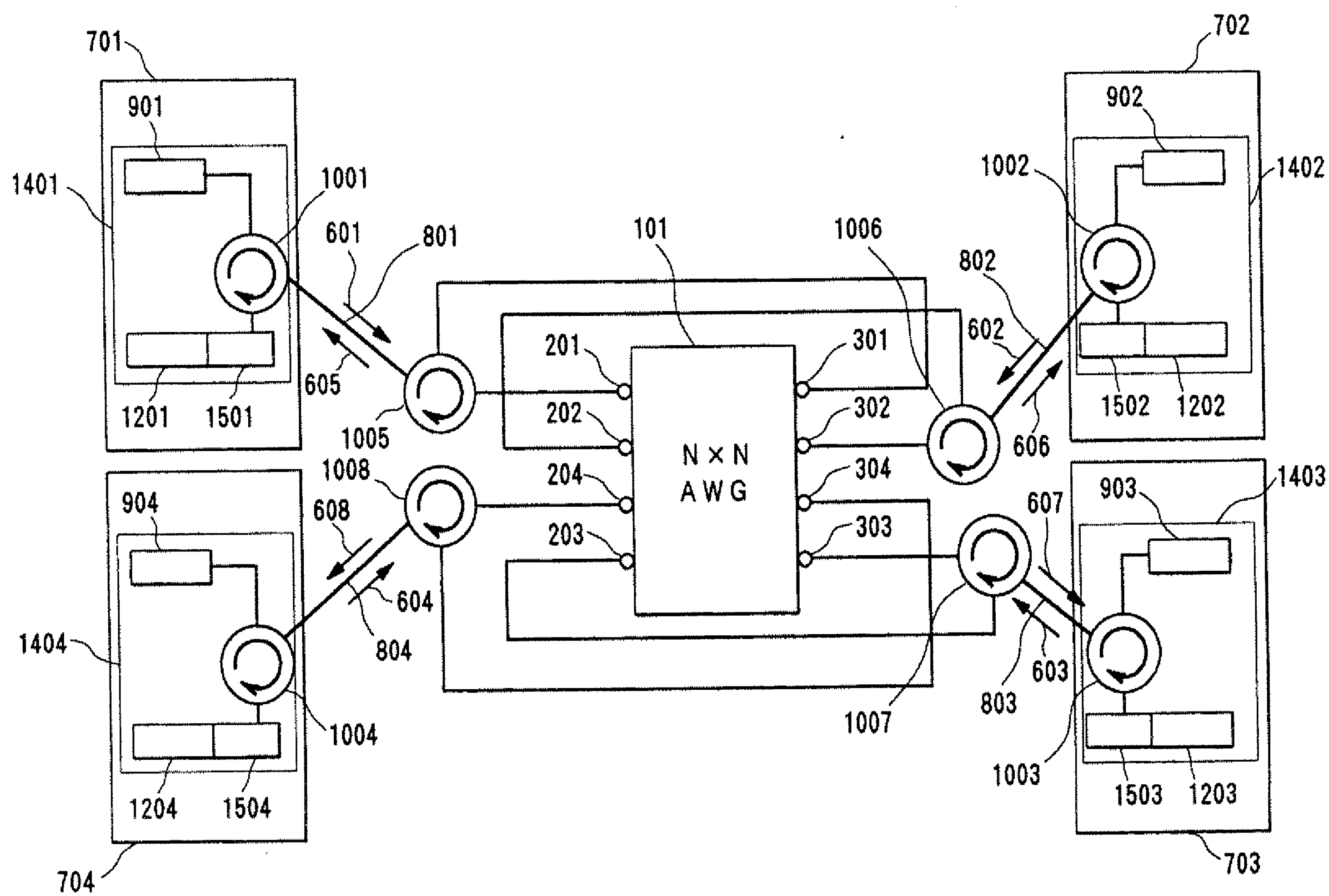

701
700b
700a
MAC
MAC
WDM-IF
700c
702
700a
700b
WDM-IF
MAC
MAC
700c
AWG
λ2
λ4
λ2
λ4
λ2
λ4
λ2
λ4
700c
MAC
MAC
WDM-IF
700b
700a
704
700c
WDM-IF
MAC
MAC
700a
700b
703

FIG. 30



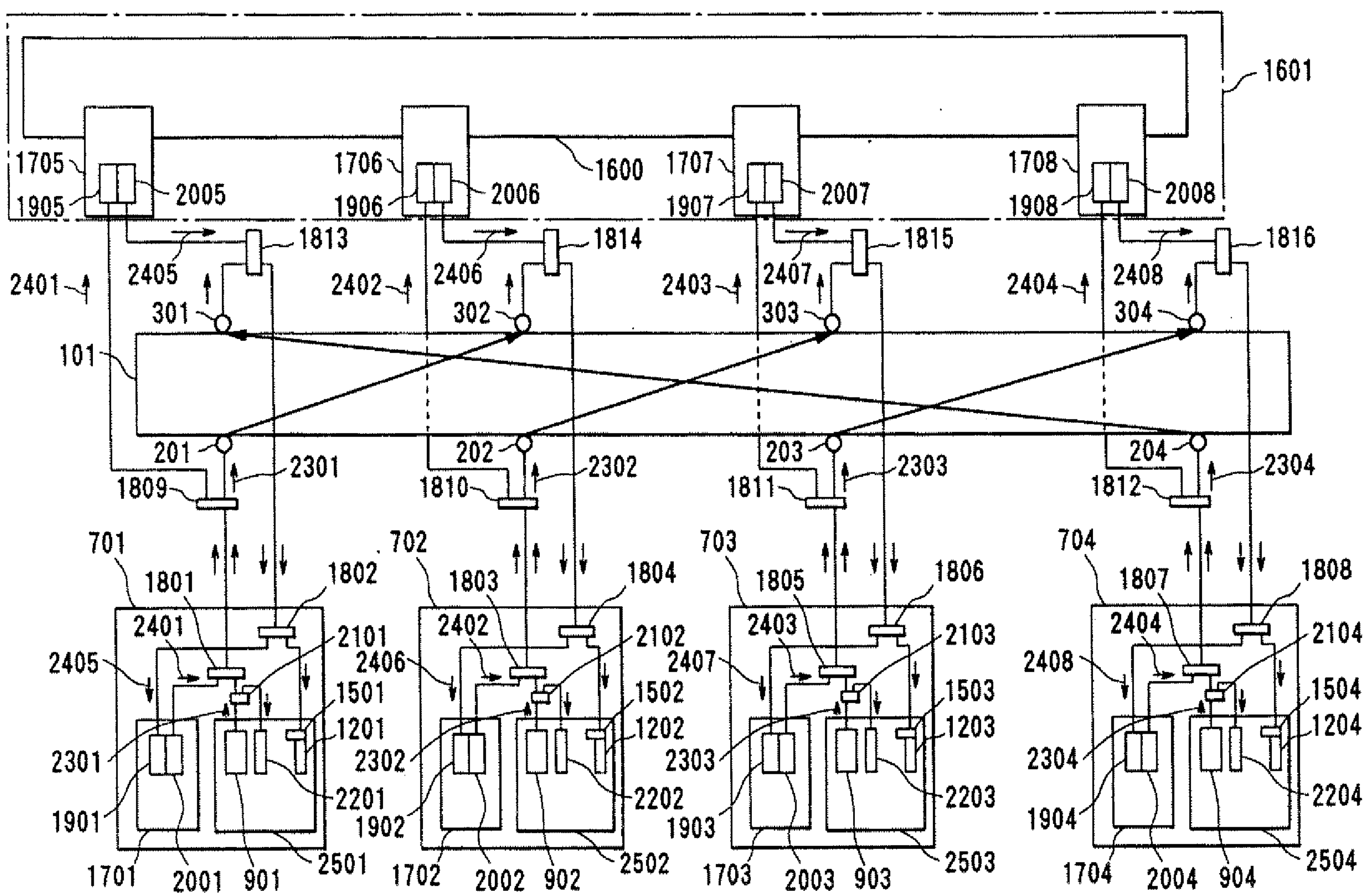
701
700b
700a
WDM-IF
MAC
MAC
700c
702
WDM-IF
700a
700b
MAC
MAC
700c
λ1
λ1
λ2
λ2
704
700c
MAC
MAC
700b
700a
WDM-IF
λ4
λ4
703
700c
MAC
MAC
700b
WDM-IF
700a

FIG. 31



701
901
1401
1001
601
801
605
1005
1201
1501
101
N × N
A W G
201
202
204
203
301
302
304
303
1006
702
902
1002
1402
802
602
606
1502
1202
1008
704
904
608
604
804
1404
1004
1204
1504
1007
703
903
1403
607
603
803
1003
1503
1203

FIG. 32


1601
1600
1705
1905
2005
1706
1906
2006
1707
1907
2007
1708
1908
2008
1813
1814
1815
1816
2405
2406
2407
2408
2401
2402
2403
2404
301
302
303
304
101
201
202
203
204
2301
2302
2303
2304
1809
1810
1811
1812
701
702
703
704
1801
1802
1803
1804
1805
1806
1807
1808
2101
2102
2103
2104
1501
1502
1503
1504
1201
1202
1203
1204
1901
1902
1903
1904
2201
2202
2203
2204
1701
1702
1703
1704
2001
2002
2003
2004
901
902
903
904
2501
2502
2503
2504

[Document Type] Abstract

[Abstract]

[Problem to be Solved by the Invention] To realize an optical communication network system easily realizing flexible network design, construction, and operation, allowing different networks to be easily connected to each other, and assuring high security and stable operation in case of failures on a simple network structure.

[Means for Solving the Problem] Multiple communication terminal nodes 401-404 are connected to a wavelength routing device 101 receiving signal light at the input ports and sending it from a specific output port depending on the wavelength thereof via optical fibers 501-505. The correspondence between the signal light wavelengths used by the communication terminal nodes 401-405 for communication and the input/output ports of the wavelength routing device is determined and the communication terminal nodes 401-405 are provided with a means for switching the signal light wavelength for communication so that the communication terminal nodes 401-404 constitute a specific logical topology.

[Selected Drawing] Fig.1